SUBJECT INDEX TYPE C-3 TRAINER

HANDBOOK OF INSTRUCTIONS

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August 1, 1941

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IMPORTANT NOTICE

WHEREVER POSSIBLE, ALL CORRESPONDENCE IN REGARD TO LINK TRAINERS SHOULD CONTAIN THE TRAINER TYPE DESIGNATION AND TRAINER SERIAL NUMBER. WHERE PARTS ARE INVOLVED, CORRECT PART NUMBERS AND PART NAMES SHOULD BE GIVEN. IF SUB-ASSEMBLIES ARE INVOLVED, ON WHICH SERIAL NUMBERS ARE SHOWN, THESE SERIAL NUMBERS SHOULD ALSO BE FURNISHED.

LINK

Instrument and Radio

TRAINER

Type C-3

HANDBOOK

Link Aviation Devices, Inc.

Binghamton, New York

281
612

Notice

Recently difficulty has been experienced in obtaining scheduled deliveries on copper wiring to conform with specifications. There is no present indication that this situation will improve in the near future and, in order to maintain our delivery schedule, we may be faced with the necessity of using wire in the Trainer that does not have the same color coding called for in our blueprints and Handbook wiring diagrams.

Since it would be an almost impossible task to have corrected wiring diagrams prepared for each Trainer where such a change is involved, it is suggested that extreme care be exercised when replacing parts involving the electrical system. In order to insure proper electrical connections, a continuity check should be made of the wiring involved rather than relying on the color code for accuracy.

September 1, 1942

LINK TRAINER

Power Information

Normal running load, 50-60 cycle, 110-120 volts	1200 watts
Line fuse recommended	20 amperes

Connection to power lines should be conduit or BX cable. Wire size; #12 if run is less than 100 feet, - #10 if more than 100 feet.

Where other than 110-120 volt 60 cycle current is to be used the Trainer is normally ordered and equipped with the necessary accessory transformers, etc.

BE SURE THE POWER TO BE USED AGREES

WITH DATA ON THE TRAINER NAME PLATE

January 1, 1942

FOREWORD

As the rapidly growing aviation industry advanced and the need for great skill in "Instrument Flying" became increasingly apparent, it gradually became obvious that this new phase involved an entirely new technique; and new methods of training were sought.

It soon became known that to fly "On Instruments", a pilot had to learn all over again. It was like learning a new language - because one had spoken English for several years, it was no indication he could learn Russian overnight. Experienced pilots soon discovered they could not fly on instruments without sensibly the same amount of practice as the veriest beginner.

It has been stated that approaching an airport "on instruments" and maneuvering "down through" by radio requires as many and complex movements on the part of the pilot as are required of a concert organist. It is also said that flying on instruments is purely mechanical; that the pilot is in the position of a switchboard operator who has a panel in front of him filled with meters, and a separate control - worked by hand or foot - for each meter. As in the case of the organist, only by long and careful practice may the pilot acquire the necessary degree of coordination of sight, hands, feet, and hearing.

From twenty-five to sometimes as much as fifty hours of practice under the hood in the air was necessary for a pilot to become proficient at instrument flying. The expense of such training and the time required, plus the fact that the mechanical nature of instrument flight lends itself to practice under simulated conditions, led to the development and manufacture of the Link Radio, Instrument and Navigational Trainer.

Experience has proven that the flying time necessary to become qualified on instruments can be reduced by more than fifty percent through proper use of the Link Trainer; also that more can be accomplished in the Trainer in a given period of time than in an airplane. For example, to aid the beginner, radio range signals may be exaggerated by the instructor to reduce the fumbling and misinterpretation of signals common in the early stages of orientation. As the student progresses and his perceptions sharpen, the signals can gradually be made to duplicate those heard in actual flight.

At this point, it should be emphasized that the instructor should be one who is himself well qualified in the subjects he is teaching.

After the student has complete control of the instruments in the Trainer and has mastered the intricacies of radio range orientation, radio direction finders, etc., he should be able to do similarly in an airplane. He will, however, go through a period of transition. It should be remembered that "feel" and acceleration forces have been purposely left out of the Trainer so that the student is one hundred percent dependent on the instruments and his control of them. During

his first hour or so of actual flight under the hood, the student will find it difficult to ignore "bumps" and other physical sensations and to make only such corrections as are indicated by the instruments. The progress he has made as a result of practice in the Trainer should not be judged by his performance during this transition period. Rather, he should be accompanied by an instructor who recognizes the condition and who will coach him to ignore these new sensations and continue to do only what the instruments demand. This transition period seldom occupies more than two hours, after which the student does an excellent job.

Since the time required to become expert on instruments is several times that usually needed to first "solo", it is logical that more practice at more frequent intervals is necessary than is the case with ordinary contact flying. Many pilots do very little instrument flying under actual conditions and will become "rusty" in a short time without practice under the hood. A large proportion of such practice may be done to good advantage in the Trainer, especially when dealing with orientation problems and "brushing up" on let-down procedures at airports not frequently visited. Any range station may be simulated, with mountains or other obstructions appearing on the chart and the beams on their proper bearings.

Years are usually required for a pilot to accumulate a few hundred hours of instrument flying. Pilots who take several years to build up a few hundred hours of ordinary contact flying seldom become masters of the art so it appears logical that students of the much more difficult art of instrument flying will continue in the "amateur" stage unless much time is devoted to practice at frequent intervals. The fact that one was proficient three months ago should by no means be taken as evidence of present ability.

In order that full value be obtained from use of the Link Trainer, it should be obvious that it must be PROPERLY MAINTAINED. A highly developed mechanism cannot be expected to continue to function without proper MAINTENANCE. Maintenance of the Trainer is neither difficult nor expensive if properly done. Any adjustments that might be required from time to time can be quickly and easily accomplished. Most difficult for the maintenance man to learn is what not to do. MANY OF THE LINKAGES AND ADJUSTMENTS ARE INTERCONNECTED, AND THOUGHTLESSLY "MONKEYING" WITH THE WRONG ONE MAY EASILY DISRUPT SEVERAL OTHERS.

THE MAINTENANCE MAN WOULD DO WELL TO OBSERVE TWO PRECAUTIONS: STUDY CAREFULLY THE SECTION OF THE MANUAL DEALING WITH THE PART IN QUESTION TO MAKE SURE HE IS ABOUT TO DO THE RIGHT THING AND THEN, BEFORE MAKING THE ADJUSTMENT, MARK IT SO HE CAN PUT IT BACK AS IT WAS IN THE EVENT HE IS WRONG.

There is nothing mysterious about the mechanics of the Trainer; it employs principles that are in daily use elsewhere. The APPLICATION of these principles is, however, sufficiently different so that anyone not thoroughly familiar with the Trainer should NEVER ATTEMPT REPAIRS OR ADJUSTMENTS WITHOUT FIRST CAREFULLY STUDYING THE MANUAL.

GENERAL DESCRIPTION

The Link Trainer consists of a fuselage with wings and empennage, mounted on a universal joint in such a manner as to permit movement in bank and pitch in excess of maneuvers normally done on instruments. The universal joint is mounted on a turn table which is free to revolve indefinitely about a vertical axis. Movement around any of the three axes or combinations thereof is controlled as in an airplane, by wheel (or stick) and rudder pedals, attached to valves which in turn control vacuum operated bellows. Vacuum is supplied by a three quarter horsepower electric turbine located in the base of the Trainer.

"Altitude" is created by partially evacuating the air from a tank. This "altitude" is governed by suitable valves through a differential linkage in such a manner that indications of altitude are the result of nose-up or down attitude and throttle setting. This differential linkage also causes proper indications of air speed and engine speed, while rate of change in altitude is also shown by the vertical speed indicator. Directional Gyro and Turn Indicator are vacuum operated as in an airplane. Since centrifugal force is not present, the Horizon is pendulum operated. Lacking centrifugal force to operate the bank indicator, the inclinometer is linked to the turn indicator.

The unsteadiness of an airplane is reproduced in the Trainer by means of a "Rough Air" device which simulates "bumps" and stormy conditions.

The complete installation includes an instructor's desk which houses the electrical apparatus and controls for producing radio signals and two-way voice communication.

An ingenious method of tracing on a map the course the student would have flown had he been actually aloft in an airplane is provided by the Flight Log, or Recorder, which operates on the instructor's desk. The Recorder is electrically connected to the Trainer and faithfully records on the chart or map each turn or course "flown" by the student. This instrument travels on three wheels, geared together so that directional control is effective with all three wheels at the same time from the one master, synchronous reversible motor. Power is supplied for driving by two constant speed synchronous motors geared to the two driving wheels. The third wheel, an idler wheel, is supplied with an ink roller and does the marking on the chart according to movements of the Trainer.

The cabinet located on the desk contains duplicate air speed and vertical speed indicators and an altimeter.

CHAPTER I

SELECTION OF SITE, UNPACKING, ASSEMBLY, INSTALLATION TEST AND GENERAL OPERATING INSTRUCTIONS.

SECTION I

SELECTION OF TRAINER ROOM

Care in the selection of the Trainer Room can often materially improve the efficiency of operation and reduce the work of installation.

Unless a large freight elevator is available, a room on the ground floor is preferable. Otherwise, it might be necessary to dismantle the Trainer and move it in sections. While this is not impossible, it is recommended that only a factory representative attempt it.

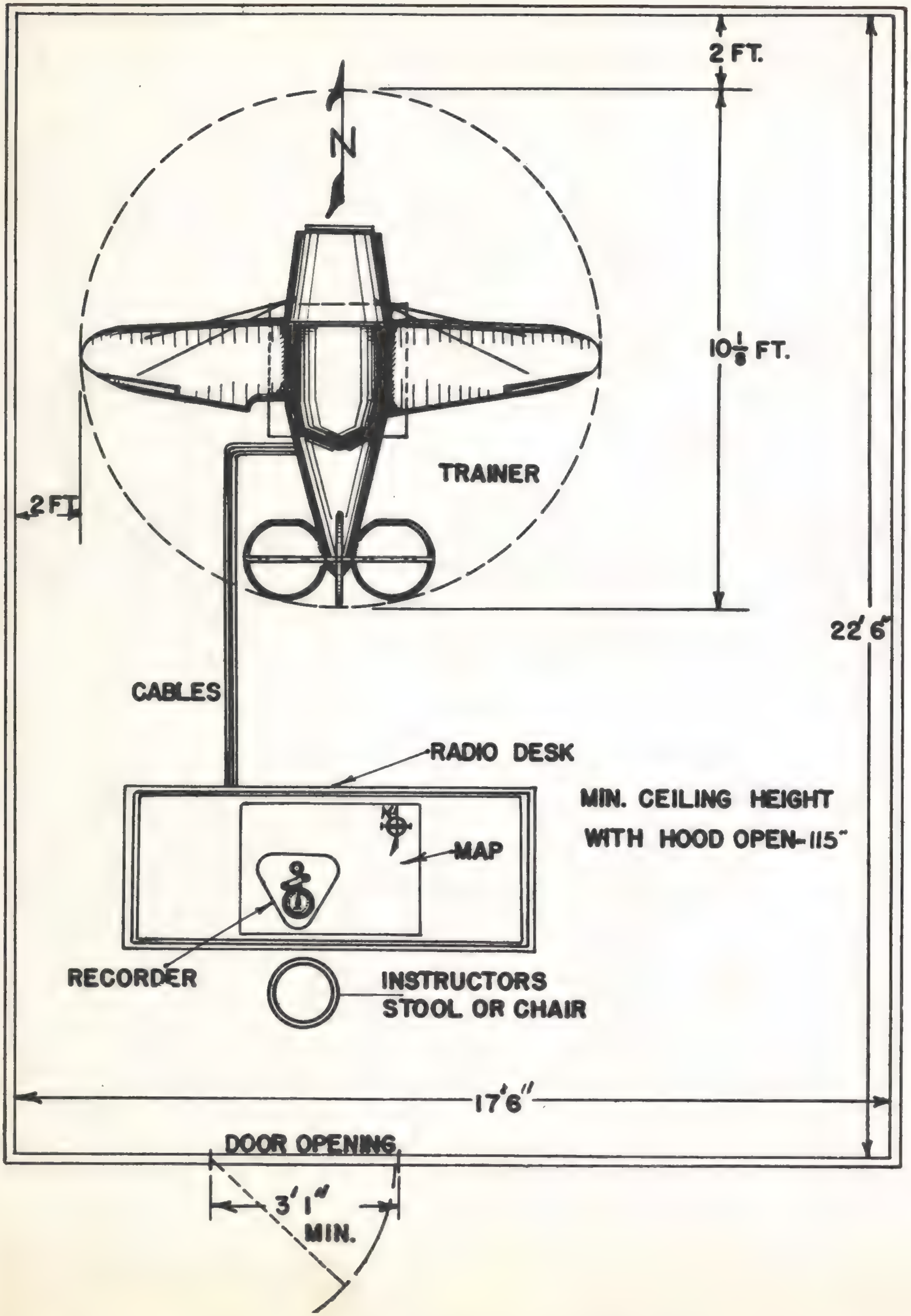
While the Trainer may be operated in a room as small as 14 x 19 feet, it is preferable that the space be not less than 22'6" x 17'6" (See Figure 1). The added space will be found to be very useful.

The room must be heated to normal room temperature and must be reasonably free of dust. For example, if the room is adjacent to a dusty airport or runway, open windows should be equipped with one of the various air cleaners available. Care in this respect will pay dividends in the form of longer operating life and more trouble-free operation. It should be borne in mind that the Trainer is vacuum operated and that eventually all the air in the room, and any floating dust particles, will circulate through the valves and bellows. This could clog needle and regulating valves and would be almost sure to cause undue wear of all moving parts.

For most efficient operation, the room should be well lighted and ventilated.

Since many of the problems and exercises worked by students in the Trainer involve the use of the magnetic compass, it is desirable that the Trainer Room be located as far as possible from large transformers and other heavy duty electrical apparatus, and away from large movable masses of metal such as aircraft engines. Such interference causes the compass indications to vary from day to day and renders it impossible to utilize an accurate deviation card.

The minimum door size through which the Trainer will pass without dismantling is 37 inches.



SUGGESTED C-3 TRAINER LOCATION & ROOM SIZE AUG. 1, 1941

FIGURE 1

Minimum ceiling height necessary with hood up is 9'7".

While not essential, it is desirable to select a room which runs north and south. This makes it possible to locate the Trainer so that, with the map right side up on the desk, north on the map coincides with north on the Trainer compass.

Other furniture and equipment needed to make the installation complete includes a filing cabinet, of the type used for storing blueprints, for storing maps and tracings; a storage cabinet for books, spare instruments, etc., and extra chairs and headphones so that additional students may sit around the desk, listen in and observe operations.

SECTION II

UNPACKING TRAINER

A certain routine order is followed at the factory in packing the Trainer for shipment. Unpacking is a simple job if the reverse of this order is known and followed. It is recommended that the following directions be CAREFULLY ADHERED TO. Otherwise, considerable damage may result.

The box containing the Trainer should be moved as near as possible to the site selected for the Trainer Room, in order that the Trainer be moved as little as possible after removal from the box.

1. Remove the side of the box marked "Remove this side first" by extracting the nails all the way around this side. If there is room enough, the bottom row of nails may be left in and broken loose by pulling the side of the box down.

2. Remove the other side of the box in the same manner.

3. With the sides of the box removed, the wings will be found standing on end against the sides of the rear end of the fuselage. The root fittings of each wing are attached to a small piece of board which is part of the crate. Unscrew these small boards and remove the wings.

4. Remove the packages attached to the front end of the box.

   CAUTION: DO NOT YET ATTEMPT TO REMOVE THE COCKPIT HOOD, the large package under the nose of the fuselage.

5. Remove all nails from the BOTTOM of the end sections of the box.

6. Remove all nails that are driven down through the top of the case into the five 2 x 4 inch uprights.

7. The ends and top of the box may now be lifted and carried sideways away from the Trainer.

8. Remove the desk, being careful to turn it completely right side up before resting any of its weight on the legs.

9. Remove all small boxes of accessories.

10. Remove cockpit hood.

11. Remove paper wrapping from Turning Motor, which was under the cockpit hood. To avoid damage to the Turning Motor, its metal cover should be located immediately and put in place.

12. Remove the 2 x 4 upright at the rear of the fuselage.

13. Engage side locking strap on left side of Trainer; then remove the two 2 x 4 uprights that form the cradle that supports the REAR of the fuselage.

    WARNING: In removing this cradle, be sure that the Icing Valve, a small valve located under the right hand rear longeron, is not damaged.

14. Remove the front cradle. Nose the Trainer down slightly and this cradle will slip over the nose. Then engage the rear locking strap, located under the rear of the fuselage.

15. Remove all four panels from the base of the Trainer.

16. Four lag screws which secure the Trainer to the bottom of the box must be removed. These are located near the corners of the Trainer base and extend down through the metal corner braces of the base.

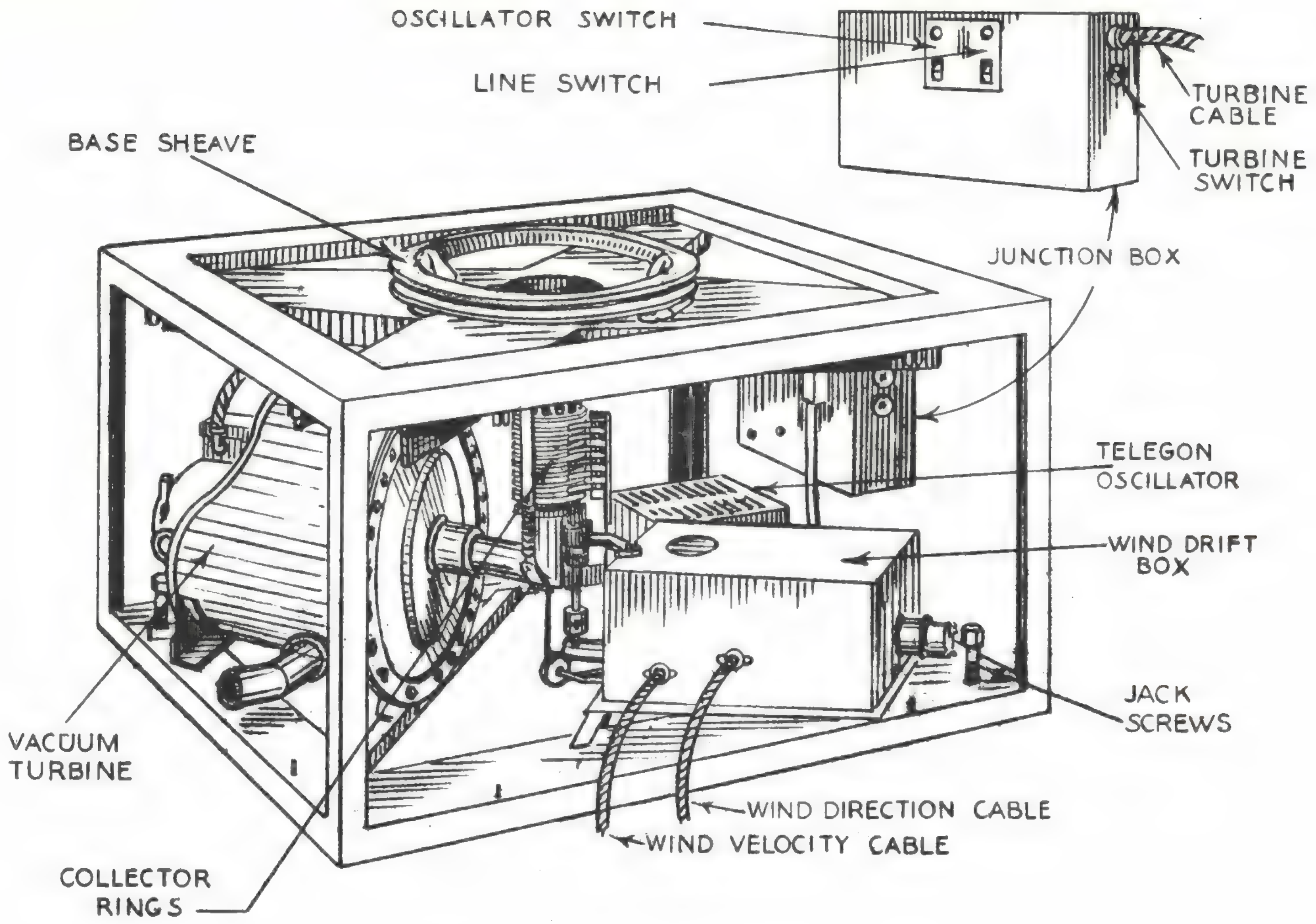
17. Remove any further boxes found stored in the base except the one with wires connecting it to the brushes on the Collector Ring Assembly.

18. Slide Trainer off the floor of the box to the part of the room where it is to be set permanently.

19. Remove the two wooden blocks under the Turning Motor supporting arms.

20. Remove four lag screws that extend up through the top of the Trainer base into tapered wooden blocks between the base and revolving octagon, and remove the blocks. These blocks can easily be loosened by turning the Trainer a quarter turn to the left.

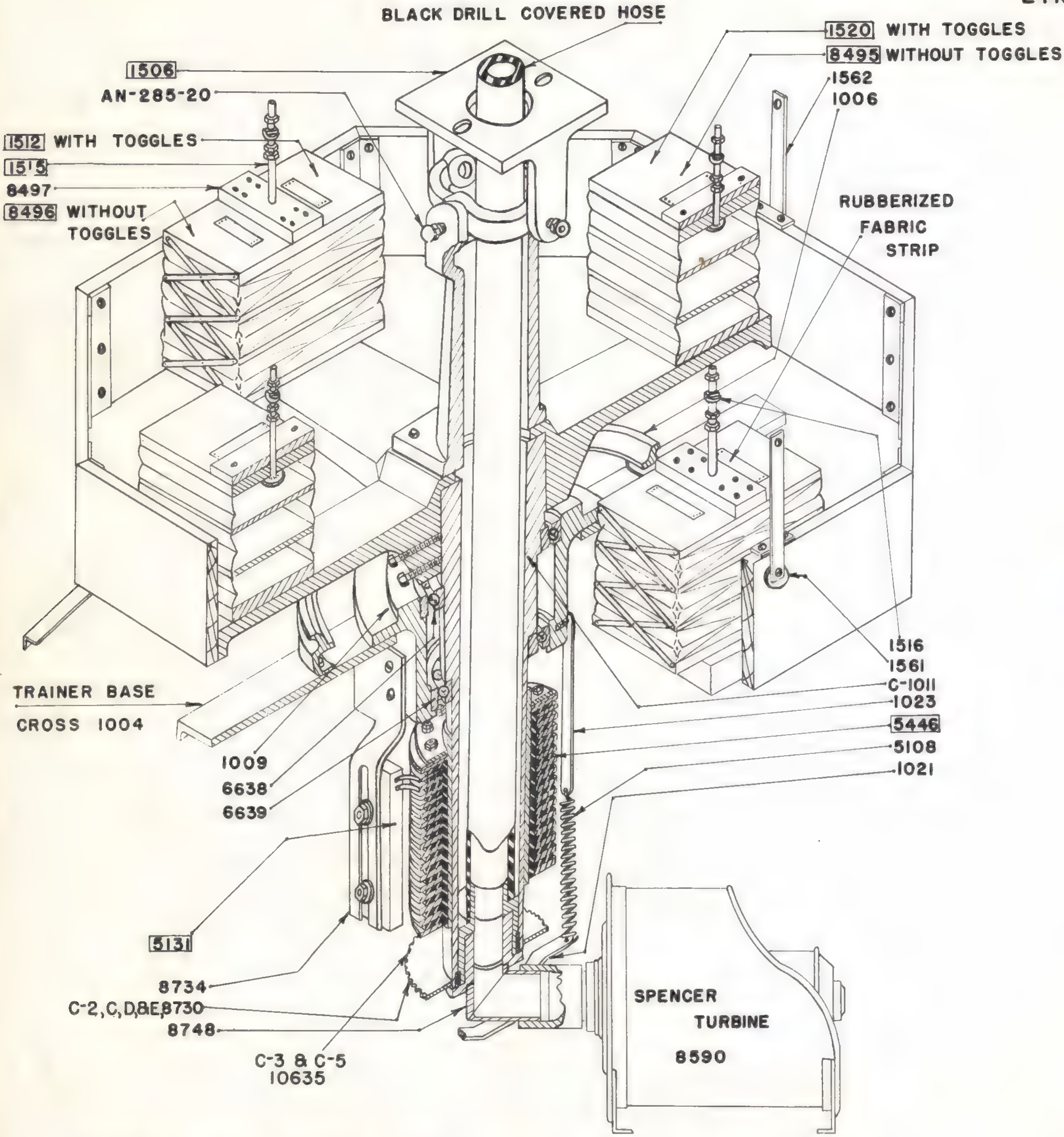
21. Check the brushes in the base of the Trainer to be sure they are riding the slip rings and have not fallen between the rings.



TRAINER BASE SCHEMATIC

JAN. 15, 1943

FIG. 2.1



MAIN BELLOWS, SPINDLE AND COLLECTOR RING ASSEMBLY

FIG.- 3

AUG. 1, 1941

L-140

SECTION III

ASSEMBLY AND INSTALLATION

The Trainer should be unpacked and in the room it is to occupy and the crating materials cleared away.

Move the Trainer to its final location (preferably the North end of the room).

Rotate the fuselage slowly one complete turn to be sure it turns freely.

Head the Trainer North by its own compass and turn, or slide, the base around until the switch box in the base faces the general direction of where the Trainer desk will be installed. Square up the base with the fuselage, with the compass still on North. (No outside compass or exact magnetic North line is needed.)

Attach left wing first and adjust the wing struts until the door fits properly.

Attach right wing and adjust struts until right wing tip is same height above floor as left wing tip.

Attach tail surfaces and hook up. Struts and rods are tagged.

Attach cockpit hood and, for safety, cotter pin immediately.

Desk Lamp Bracket & Recorder Cable Supporter

The desk lamp bracket contains the wiring for the desk light and the 12 wire Recorder cable. After attaching the lamp bracket to the desk, it will be necessary to attach the wire ends to the correct terminals in the junction box under the desk. Refer to Figure 58 and connect each wire to its terminal by reference to the color coding and terminal block number.

In Fuselage

Remove the two wooden blocks screwed to fuselage to hold seat during shipment, and remove seat. The seat removes easily if lifted straight up until it clears the door sill.

Remove safety wire from the inverted valve pendulums.

The control wheel or stick is prevented from moving in shipment by closing the slipstream simulator needle valve. This valve should be opened slightly before attempting to move the elevators. (See "Resistance Adjustment", Figure 21 .)

Replace seat.

Remove Artificial Horizon. Remove locking screws and fill dash pots. (See Chapter 3, Section 6.)

Compensate Compass. (See Chapter 1, Section 6.)

Leveling Trainer

In order that the instruments function properly, the Trainer should be carefully leveled. Four jack screws are provided on the corners of the base for this purpose. (Figure 2.1)

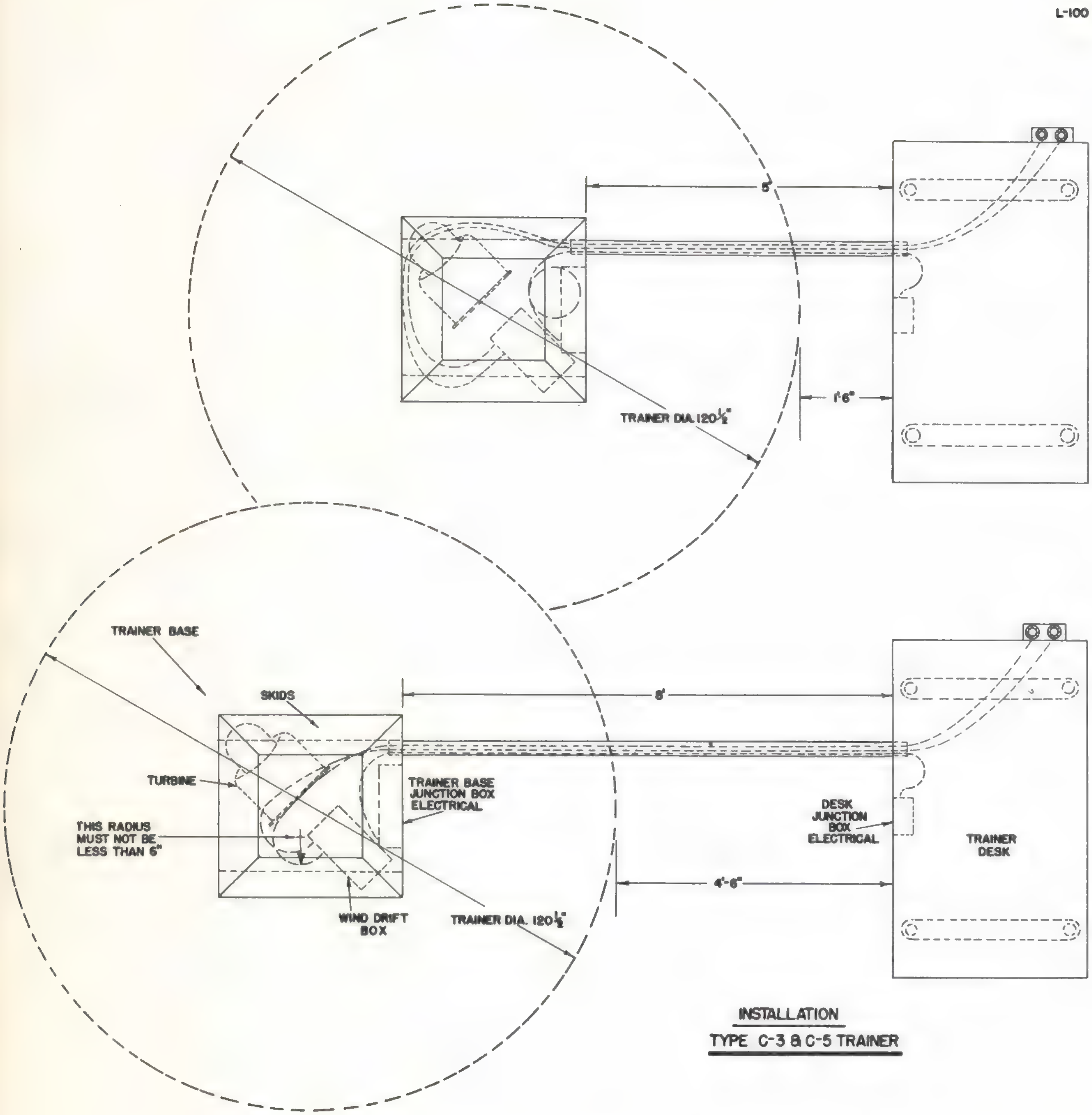
A carpenter's level should be laid on the edge of the revolving octagon and the Trainer turned until the level approximately parallels one side of the square base.

Note the position of the bubble in the level and rotate the Trainer 180 degrees. If the Trainer is level, the bubble will still be in the same spot, even though not in the exact center of the glass. If the bubble changed position, raise the low side of the Trainer indicated by the level, by screwing down on the two leveling screws on the low side as necessary. When the Trainer is level in the direction first attacked, turn to a heading 90 degrees from it and level the Trainer in that direction.

When the Trainer is properly leveled, the bubble in the spirit level will not change position while the fuselage is turned through 360 degrees.

Connection to Power Supply

Connect a No. 14 two conductor BX cable to the nearest supply line, fused for 20 amperes. The BX cable should be led under one side of the Trainer base and connected to the junction box through a fitting provided there. The two wires of the cable should be connected to L1 and L2 in junction box. It will not be necessary to consider any polarity.



INSTALLATION
TYPE C-3 & C-5 TRAINER

FIG.-3.1 AUG. 1, 1941

SECTION V

INSTALLATION OF RADIO AND DESK LIGHT

The radio equipment involves one assembly which is installed in the middle drawer of the radio desk. This unit is provided with one simple plug-in connector connecting the radio and desk terminal in the back of the desk.

Place the radio chassis in the middle drawer and connect large plug-in connector to the back of the radio chassis. NOTE: Before connecting any plugs or cables, be sure that all switches are turned to the off position.

Next install the tubes if they are packed separately. The tubes must be installed in their proper sockets as shown in Figure 6. This figure shows the tube numbers and where the tubes should be plugged in. (Tube numbers will be shown on the base of the tube.) The instructor's earphones and microphone plug into jacks located on the right hand corner of the radio chassis. Additional jacks are located around the outside of the desk so that several additional pairs of phones may be plugged in. (CAUTION: If these headphones are replaced or additional pairs are used, they must be of 2000 ohms impedance.)

Desk Lighting Fixture

The fixture which supports the lamp over the Trainer desk, and which also carries the Recorder cable, should next be bolted to the back of the instructor's desk in the position shown in the frontispiece. The Recorder cable was merely pulled through this fixture sufficient to allow slack for packing purposes but was not disconnected from the terminal box. In addition to this Recorder cable, there are two wires which supply 110 volt current to the lamp. These wires were disconnected for packing and must be reconnected to terminals 1 and 2 on the desk terminal block in the junction box located in the back of the desk, as shown in Figure 58. Since this is alternating current, it does not matter which wire goes on which of the two 110 Volt terminals.

SECTION VI

COMPENSATING COMPASS

Head Trainer North by its own compass, and see that the square Trainer base lines up with the fuselage. This should be checked carefully so that the base may be used as a "compass rose", to "swing ship" on the cardinal points. This alignment can be checked by sighting down past the side of the fuselage, seeing that it parallels the base.

No other compass or North-South line is necessary.

After the base is squared up with North as indicated by the Trainer compass, turn the fuselage 90 degrees to the right and line the side of the fuselage up with the base. Using the E-W compensator screw, adjust the compass to read exactly East.

Next, have an assistant turn the Trainer another 90 degrees to the right and line it up again with the base.

The compass should now read South but if there is any iron work in the building, or other magnetic interference, an error will be present. Using the N-S compensating screw, reduce the error by one half its amount. This will divide the error between northerly and southerly headings.

Next, turn the Trainer to a westerly heading and line it up with the base. If the compass does not show exactly West, split the error as was done on the South heading.

Deviation Card

While making out the deviation card, the hood should be closed and the Trainer running, but with the locking straps left on.

The rudder must be in neutral to prevent the Compass Deflector, (which simulates northerly turning error), from operating.

It is essential to have an assistant stand outside the Trainer and swing it to the desired headings and hold it steady while the compass settles down.

Have the assistant head the Trainer North and line it up with the base. Set the Directional Gyro to exactly zero. After the compass has settled down, note down its heading.

Have assistant turn the Trainer to a Gyro heading of 30 degrees, wait for the compass to settle and note down its heading.

Turn to a Gyro heading of 60 degrees and repeat the process.

Turn to an easterly heading and line up with the base. Note down compass heading as before, and check Gyro for a heading of exactly 90 degrees, resetting the Gyro if necessary.

Continue all the way around the Compass in 30 degree intervals as above.

If another assistant is available, time can be saved by attaching the "heading indicating pointers" to the octagon, while the deviation card is being made.

These cards should be put on at 30 degree intervals, to show magnetic heading rather than compass heading, thus affording information to the instructor as to whether the student is correcting for deviation. The heading indicating pointers should be exactly 30 degrees apart, by the Directional Gyro.

SECTION VII

INSTALLATION OF RECORDER

Remove the Recorder (Flight Log) from the lower right hand desk drawer and set it gently on the desk. Plug in the short 10 wire cable which comes out of the lamp support over the desk.

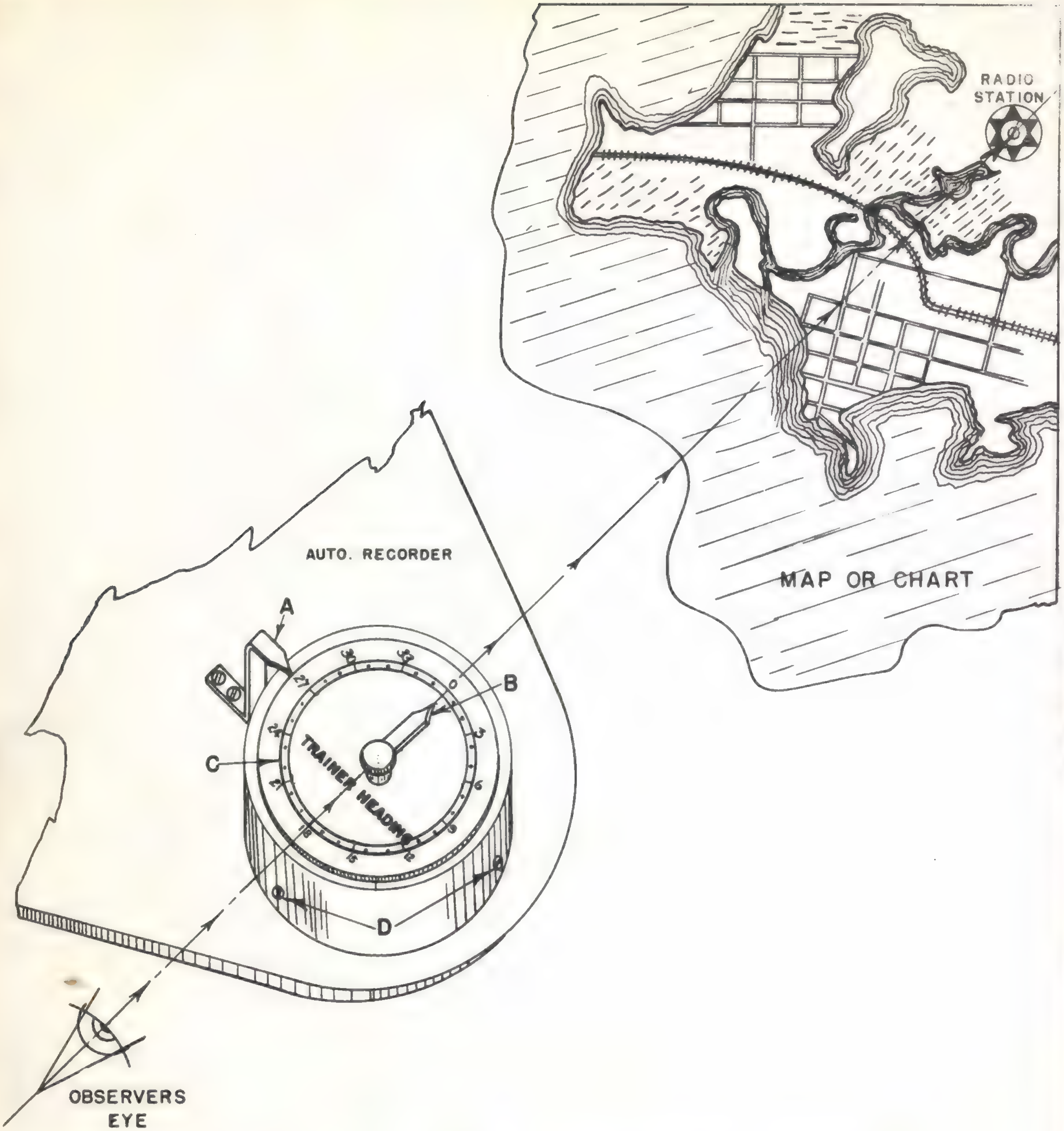
Check that the wind velocity and wind direction dials are still at zero.

In normal operation it is customary to place the map or chart on the desk with north away from the instructor. The Recorder should be placed on the chart so that the driving wheels are located east and west of each other, that is magnetic east and west as shown on the map. It is not necessary to line up map and Recorder with reference to the magnetic compass as this relationship was taken care of in synchronizing the Recorder. It is then only necessary to rotate by hand the large gears on the Recorder until the inking wheel is pointed in the same direction <u>on the map</u> as the Trainer is <u>headed by its own compass</u>, as shown by <u>the markers on the revolving octagon</u>.

If the Trainer room does not lie north and south as recommended in Chapter 1, Section 1, an extra adjustment must be made. Head the Trainer north by its own compass and turn the base around until the base junction box faces the general direction of the desk. Proceed to compensate the compass as described in Chapter 1, Section 6.

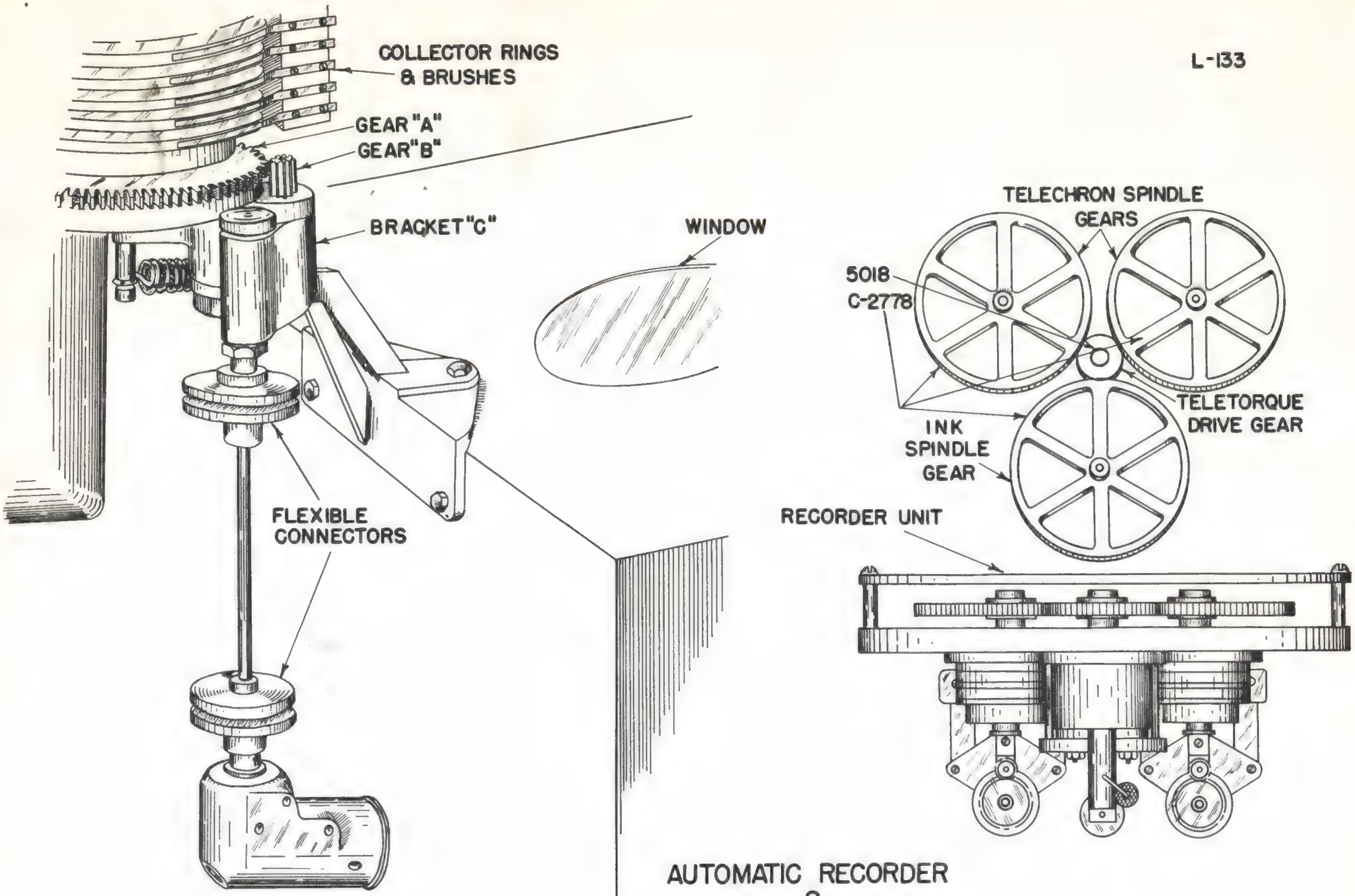
After the compass has been compensated, rotate the Trainer fuselage so that the tail is directly over the base junction box (pointed at the desk), and fuselage is square with the base.

In the base spring out bracket ("C", Figure 5.1) so that the gears "A" and "B" (Figure 5.1) just clear each other. Slowly rotate the Trainer until it is headed north by its own compass and fuselage square with the base. Allow gears "A" and "B" (Figure 5.1) to engage.



OPERATION OF RADIO COMPASS CONTROL
FOR
A RADIO COMPASS PROBLEM

FIG. 4



AUTOMATIC RECORDER
&
GEAR SYSTEM

FIGURE 5.1

AUG. 1, 1941

SECTION IX

GENERAL OPERATING INSTRUCTIONS

See that all cables are plugged in properly. Turn on the Line Switch located on the front of the base junction box marked "Line". Turn on the oscillator switch, located on the front of the base junction box (Figure 2.1), and wait about 30 seconds for the oscillator to warm up and the remote indicating instruments to "come alive". See that the altimeter on the desk agrees exactly with the one in the Trainer. (If they do not agree, see Chapter 1, Section 10, for instructions.)

Set the altimeters approximately 500 ft. below zero. (This is because the last 500 ft. of altitude decreases slowly, due to the pressure in the "altitude" tank being so close to the atmospheric pressure in the room, and the instrument lag would be too great.) This is no disadvantage as problems are considered to start or end when the altimeter reaches zero.

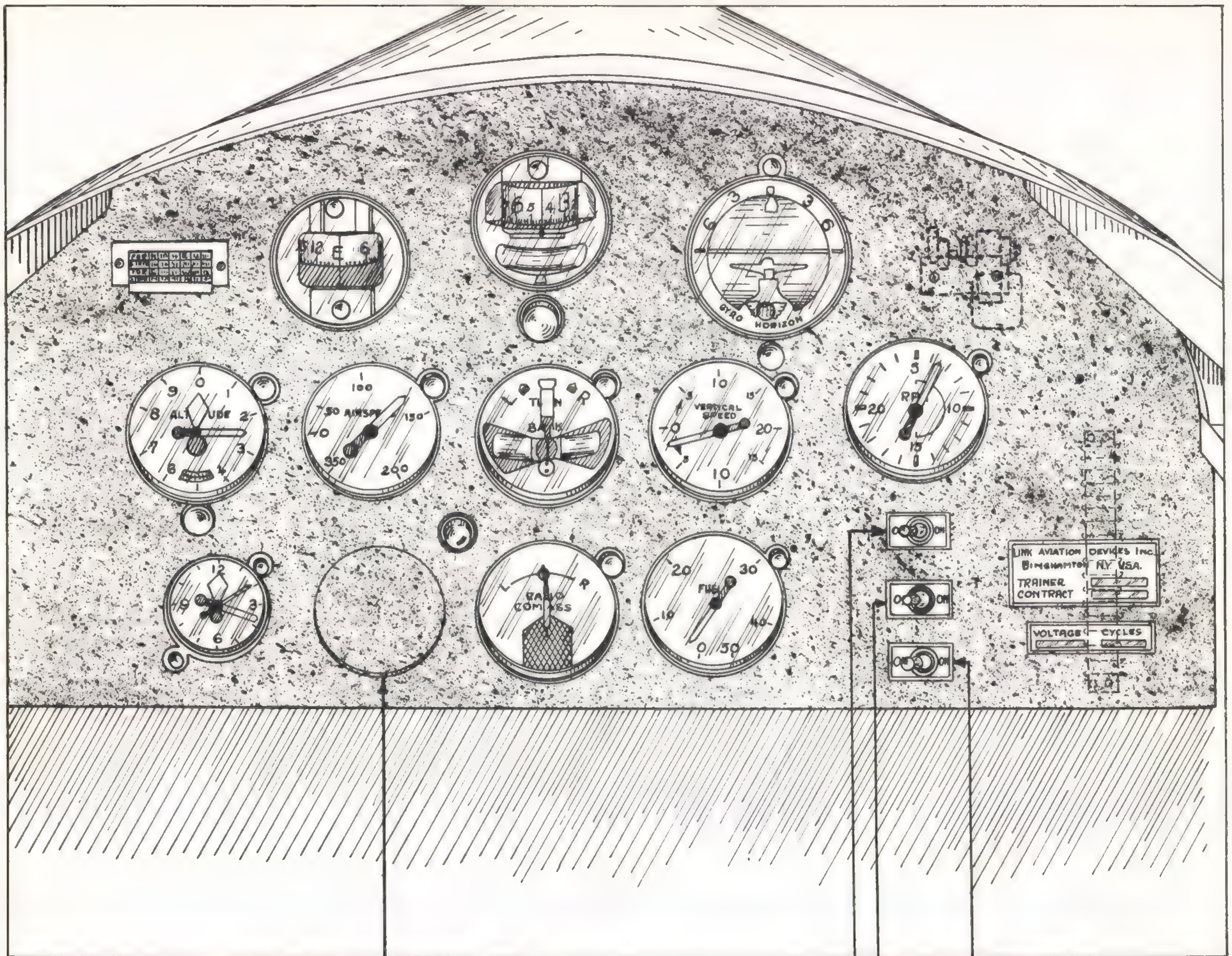
The Trainer is turned on by means of the ignition switch located on the right hand side of the instrument panel in the Trainer cockpit. Refer to Figure 5.2. Instructions for unlocking and re-locking the fuselage are given in the Instructor's Guide, Chapter 7.

By means of a key, which will be found suspended from the directional gyro caging knob on new Trainers, wind up the fuel gauge to the desired "gallons". NOTE: With the fuel switch "on" the Trainer will not run unless the gauge indicates a supply of fuel. With this switch "off" the fuel gauge has no effect on the operation.

Before putting the Trainer in operation, the side and rear locking strap should be slipped off the locking pin and laid against the hooks provided for the purpose.

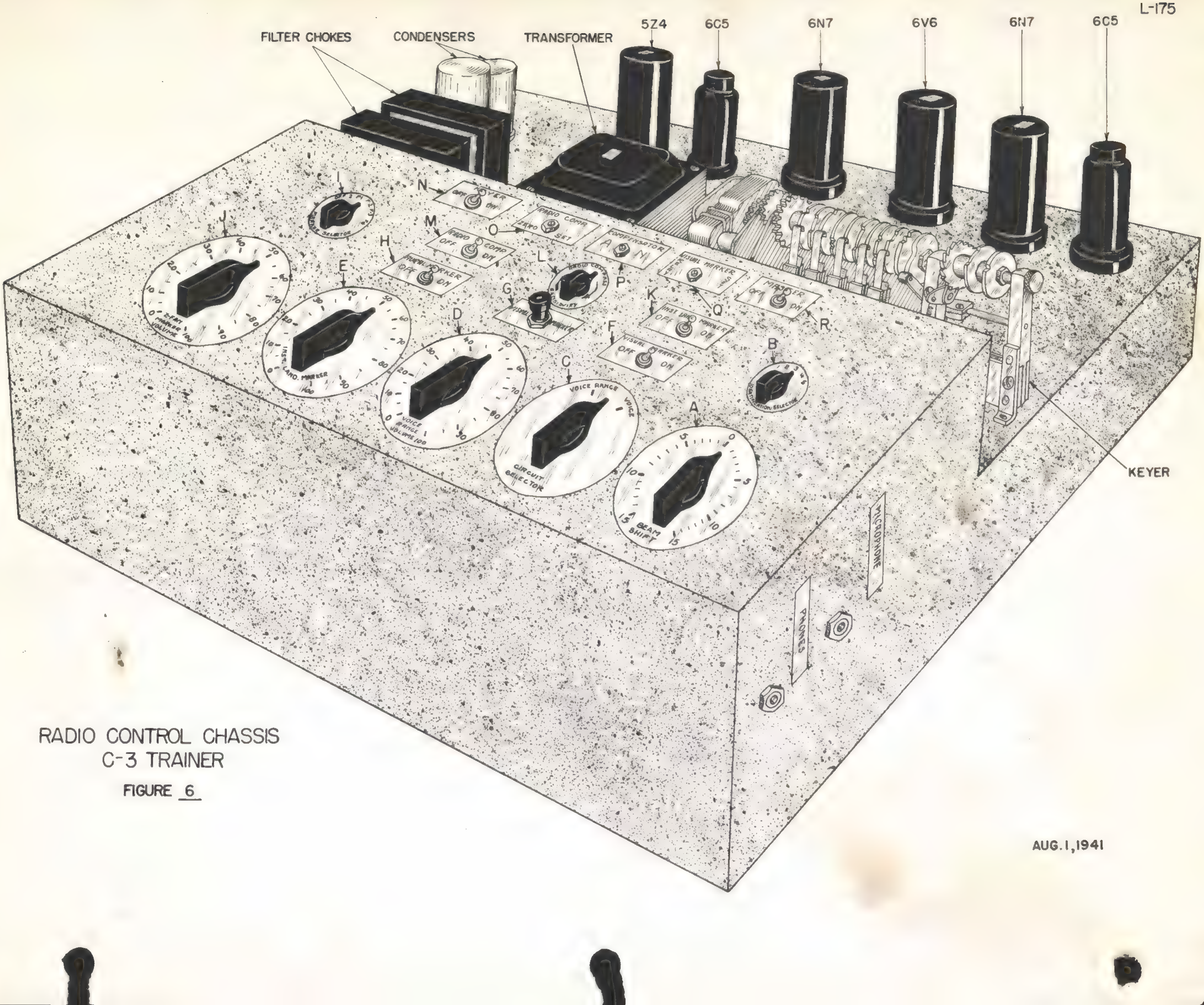
To completely release the fuselage for operation, merely turn slightly to the left the valve knob located at the bottom, on the forward side of the leveling jack on the cockpit floor. With the Recorder on the desk and connected as previously described, spin the large gears by hand until the inking wheel is traveling the same direction on the map that the Trainer is headed by its compass. When ready to actually start a problem, turn on the on-off switch located on top of the Recorder. A "rough air" mechanism is provided to simulate stormy conditions. This is located near the right rear longeron and is put in operation by screwing in on the small crank. (See Figure 7) This crank may be partially screwed in to provide varying degrees of rough air. Also located on the rear right longeron is the "icing valve". When this valve is closed, air is

INSTRUMENT PANEL C-3 TRAINER



AUG.1,1941

FIGURE 5.2



RADIO CONTROL CHASSIS
C-3 TRAINER

FIGURE 6

AUG. 1, 1941

shut off from the air speed indicator system, simulating icing conditions. For normal operation, this valve must be opened.

To re-level and lock the fuselage after a problem is completed, simply close the valve on the bottom of the leveling jack and pump the handle until it feels solid. NOTE: Don't force the leveling jack to overcome the operating pull of the main bellows: Fly the Trainer to a level position.

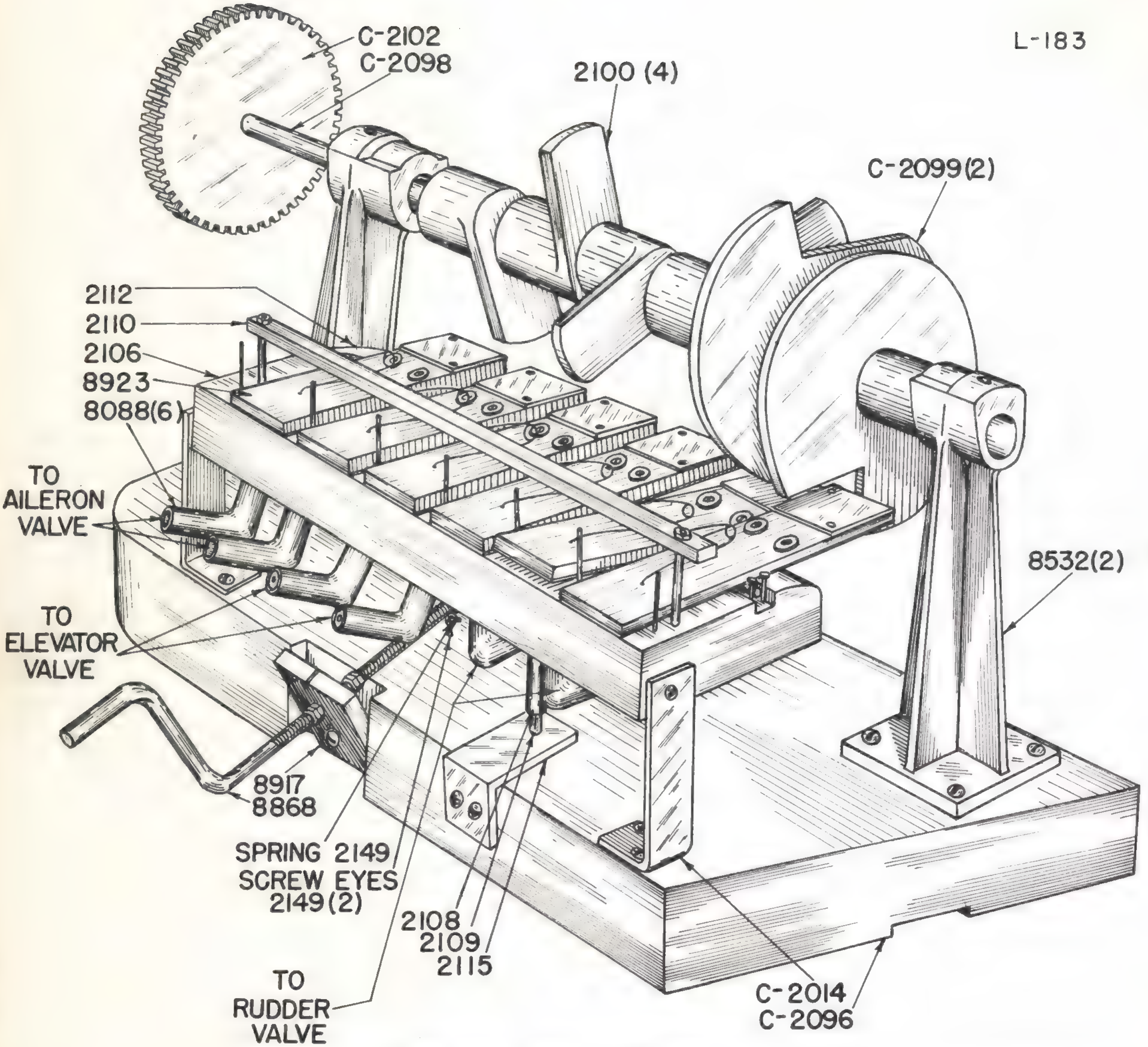
Operation of the controls and the use of the instruments is the same as in an airplane. It will be noted, however, that the Trainer has no stability and no particular feel. It is purposely built this way so that the student will be forced to fly entirely by instrument. It has been found that when a student learns to fly instruments under "no feel" conditions, it later on matters very little to him what type of airplane he flies.

Spins are accomplished, purposely or accidentally, by nosing up until "air speed" falls below the stalling speed. Recovery is made as in an airplane, by nosing down and applying opposite rudder. It will be noted that the Trainer "spins" with the nose high, instead of nose down as in an airplane. This is not important, however, as the proper instrument indications are shown, and the student under the hood cannot see the attitude and must recover by instrument.

GENERAL OPERATION OF C-3 RADIO

The radio chassis is conveniently located in the center drawer of the radio desk. Mounted on the radio chassis are various controls with which the instructor simulates various radio aids to navigation.

Radio range signals are simulated by use of the beam shift control "A", Figure 6, and choice of five different stations are possible through selector switch "B". Simultaneous range and "voice" or voice only is made possible by means of selector switch "C", while control of voice and range signal strength is accomplished by volume control "D". Visual marker signals are accomplished by automatic relay control "Q" set to actuate the relay keying device when instrument landing control "E" reaches a certain point on the dial. By pushing button "G", coded visual signals are made continuous, thereby affording universal control of visual circuit. Toggle switch "F" turns on the visual marker circuit while "H" controls the aural circuit. Z and Fan type markers are selected at switch "I" and controlled by volume control "J". Instrument landing switch "K" and radio compass "M" control the circuits. Sensitivity of the radio compass is obtained by volume control "L". The radio range and compass circuits are balanced by compensators "O" for the radio compass and "P" for radio range. The code keying device may be turned off at "N" during primary instruction or when it is not needed. The master switch "R" controls the entire unit on or off.



ROUGH AIR GENERATOR
FIG.- 7

AUG. 1, 1941

SECTION X

SYNCHRONIZING ALTIMETERS

If the Oscillator is turned off while there is still vacuum in the system and the altimeters are indicating above zero, they will remain at that setting. When the Oscillator is again turned on, the altimeters will show somewhere above zero and must be brought down. If the main switch in the Trainer is "on" and the Oscillator "off" the vibrators will sometimes cause one of the altimeters to change its reading and disagree with the other.

To synchronize the altimeters, turn on the Oscillator. Each instrument is furnished with a setting knob by which the barometric scales are adjusted. Set these scales to exactly agree. The large pointers of the two instruments should now agree even though the small pointers are out of synchronization. If the large hands do not exactly agree when the barometric scales are together, proceed as follows: Set the large hands to exactly agree. Just to the left of the adjusting knob is a countersunk screw; loosen this screw until it can be moved slightly sideways. By pulling gently out on the knob (like setting a watch) the barometric scale can be moved without disturbing the hands. Set the scales to exactly agree with each other; then replace knob and screw.

To Synchronize the Small Hands:

If one of the altimeters is too low (1500 or more feet below zero), disconnect the cable from the back of the <u>other altimeter</u>. (CAUTION: The Oscillator must be <u>OFF</u> when connecting or disconnecting altimeters.) Turn on the Oscillator and the Trainer, and climb until the low altimeter is brought to 500 feet below zero. Shut off the Oscillator and reconnect the other altimeter. Shut off the Trainer and allow about five minutes for vacuum to be lost before starting normal operation.

If one of the altimeters is <u>too high</u> when at rest, disconnect the low one. Leave the Oscillator <u>off and</u> climb the Trainer to an altitude greater than that shown by the high altimeter. (This must be estimated as the altimeters will not be working.) Turn on the Oscillator and as soon as the instruments "come alive" turn off the Trainer. Watch the altimeter that is being corrected and when it reaches approximately 500 feet below zero, turn off the Oscillator and connect the other instrument. Allow about five minutes for all vacuum to be lost before starting normal operation.

If <u>both</u> altimeters are a thousand feet or more too high or too low when <u>at rest</u>, proceed as in correcting only one but leave both connected. If both are too high or too low and one higher than the other, leave both connected and when one reaches 500 feet below zero shut off the Oscillator and disconnect this instrument. Then proceed as just outlined to correct the remaining instrument.

SECTION XI

RADIO COMPASS

With the student in the Trainer and ready, and the Flight Log moving across the map, turn on the Radio Compass switch on the power supply in left hand side rear of the desk drawer.

Rotate the round, movable scale on top of the Recorder until the zero of this scale is in line with the spot representing the radio station on the map. (Figure 4)

When the student turns the Trainer until the inking wheel is moving directly toward the radio station on the map, the pointer in the cockpit will be centered on zero. The instructor must continue to keep the 0 of the movable scale (Figure 4) pointed toward the radio station.

As the recorder approaches the station, the student should gradually increase the Radio Compass volume. When the inking wheel gets close to the station, the instructor should move the round scale very slightly. As the student turns the Trainer again to center the left-right pointer, the instructor should turn the scale slightly in the opposite direction. This causes the R.C. pointer to become difficult to manage and simulates the extra sensitivity found near the station in actual flight. The instructor should cause this "unruly" tendency of the needle to become increasingly worse until the inking wheel passes over the station.

At this point, the rotating scale must be turned 180 degrees in order to keep the "0" pointed toward the station. Turning the scale 180 degrees also has the desired effect of causing the needle to give opposite indications. When the student again turns toward the station, the needle will be automatically corrected to again give proper indications.

During practice, all movements of the rotating scale should be smooth and steady to avoid causing the needle to jerk.

CHAPTER II

DETAILS OF MECHANICAL OPERATION

SECTION I

VACUUM: WHAT IS IT ?

To clearly understand the functioning of the Trainer, a knowledge of vacuum is necessary. Vacuum, theoretically, is a space with absolutely nothing - not even faint traces of air - in it. Only partial vacuum is utilized in the Trainer - space in which only a portion of the air has been removed or withdrawn. The effect of taking part of the air out of a container is to reduce the pressure inside the container.

Normal atmospheric pressure at sea level, is 14.7 pounds per square inch. Take an "empty" bottle. This pressure is inside it, of course, as well as outside. If we put a rubber tube tightly into the neck of the bottle and suck out some of the air, pressure inside the bottle will be reduced. The pressure outside the bottle will then be greater than the pressure inside, and it will try to crush the bottle. This is what occurs with the bellows in the Trainer. When we remove some of the air from inside, the air on the outside pushes the bellows together.

If we use a tank instead of a bottle we would be able to connect a gauge to it and measure the pressure inside as compared to the pressure outside. If we had 14.7 lbs. per sq. inch outside and only 10.7 lbs. inside, the gauge would show the difference - 4 pounds of "vacuum" or pressure differential. One method of measuring the degree of vacuum is with a mercury gauge. This is a U shaped glass tube with the open ends up, filled a little less than half full with mercury. With a rubber tube attached to one of the open ends of the glass and the other end of the rubber tube connected to the tank, the height the mercury is displaced will indicate the degree of vacuum. The difference in height between the two columns of mercury in the U glass is measured in inches and the indication read as "inches of mercury". It takes roughly one pound of pressure differential to give an indication of "2 inches of mercury", or, as it is sometimes expressed, "2 Hg".

When we utilize partial vacuum we are reducing the inside pressure and it is the outside air trying to force its way in that is working for us. For example, in using the mercury gauge, the lowered pressure in the tank is connected to one end of the glass tube but it is the outside air pushing against the mercury through the open end of the glass that raises the mercury column. The column will rise until the extra weight of the lifted column equals the pressure differential; thus when we measure the column we know the pressure differential, "pressure differential" being another term for "partial vacuum".

SECTION II

MOTION OF TRAINER AROUND THREE AXES

Motion of the Trainer is permitted around three axes - banking, pitching and turning.

The Trainer unit, except the square base, is mounted on a vertical shaft, or spindle. This spindle (See Figure 3) rotates in large ball thrust bearings which are firmly mounted in the square base.

At the top end of this vertical shaft is a universal joint on which the fuselage is mounted. This permits the fuselage to bank, or nose up or down, or combine these motions, independent of whether it is turning or not. The amount of this banking or pitching is limited by stops which prevent damage when the limits are reached. There is no limit to the amount of turn around the vertical axis.

Motion around all three axes is obtained by the use of partial vacuum which is supplied by a 3/4 H.P. electric turbine located in the base of the Trainer. This turbine has a capacity of approximately 12 cubic feet of air per minute at approximately 4½" Hg.

Banking

Banking motion is obtained by two of four large bellows located under the fuselage in the revolving octagon, (Figure 3). When the Trainer is operating, these two bellows are pulling downward on the fuselage on both sides of the universal joint. As long as the downward pull is equal on both bellows the Trainer remains level, laterally.

Vacuum is supplied to these two bellows through a two-way valve. By operating this "Aileron Valve" more vacuum can be applied to one bellows while less vacuum is applied to the other, which pulls one side of the fuselage down.

This valve is connected by a compensator link rod to an arm on the torque shaft which extends along the centerline of the fuselage a few inches above the floor. A control cable connects the Control Wheel with a pulley on the torque shaft so that turning the control wheel operates the two-way aileron valve causing banking. In stick control Trainers, the stick is mounted directly on the torque shaft.

Climbing or Diving

Nose up or nose down motion of the fuselage is obtained with the other two of the four large bellows in the octagon. These bellows are located on the center line, one in front of, and the other behind the universal joint (Figure 3).

These two, like the banking bellows, are both pulling downward equally on the fuselage when the Trainer is maintaining a level position. They are controlled by a two-way "Elevator Valve" which is similar to the aileron valve. This valve is connected by a link rod directly to the bottom of the control column or stick. Consequently, pushing the stick or wheel forward moves the elevator valve and increases the vacuum in the front bellows and decreases it in the rear bellows, which pulls the nose of the fuselage down.

The two-way aileron and elevator valves are constructed so that in the neutral position, each valve is permitting a small amount of vacuum to be applied to both of the bellows it controls. (See "Main Valves", Chapter 2, Section 9.)

Turning

Turning around the vertical axis of the Trainer, is obtained by the use of a vacuum operated "Turning Motor" (See Chapter 2, Section 7, for construction details). The turning motor is mounted on arms extending out in front of the octagon under the front of the fuselage. The driving pulley on the turning motor is connected by a round leather belt to a large fixed pulley attached to the Trainer base. Thus the motor turns itself (and the fuselage) around the fixed pulley instead of, as is more usual, the motor standing still and turning the pulley.

The turning motor is reversible and is controlled by a two-way "Rudder Valve" the same as banking and pitching. This valve is connected to the rudder pedals in the cockpit so that pushing the left hand pedal gradually opens the valve in the direction that causes the turning motor to turn the Trainer to the left and vice versa.

These three main valves are constructed so that the amount of vacuum they allow to pass, and the rapidity of Trainer motions caused by movements of the controls, is in proportion to how far the controls are moved.

SECTION III

HOW INSTRUMENTS ARE ACTUATED

A sealed tank is located in the nose of the Trainer and connected to a pair of valves (called the Climb-Dive Valve Assembly) which in turn are connected one to the vacuum supply, and the other directly to open air. The valve in the vacuum supply line is the Climb Valve, and the one opening to atmosphere is the Dive Valve. (See Figure 8).

When the climb valve is opened, air is drawn out of the climb-dive tank which reduces the pressure inside the tank below atmospheric pressure in the room. A condition is created inside the tank similar to the decrease of atmospheric pressure as altitude is gained in an airplane. An altimeter connected to this tank measures the pressure differential and indicates the simulated "altitude".

When the dive valve is opened, atmospheric pressure being greater than the pressure within the tank, air will flow in. This reduces the vacuum inside the tank and the altimeter shows a loss of "altitude". The rate that altitude is gained or lost depends directly on how far the climb or dive valve is opened. As shown in the illustrations, only one valve can be opened at a time. It should be noted that the <u>dive</u> valve needle has a left hand thread.

The vertical speed indicator is also connected into the climb-dive or "altitude" tank, and measures the rate of change of pressure, indicating in terms of the rate of gain or loss of "altitude".

The climb-dive valve assembly is located on the floor of the fuselage and is actuated when the Trainer is nosed up or down. It is connected, by a "Pitch Action Compensator", down through the fuselage floor to a member in the revolving octagon (See Figures 8 and 9). Since the Trainer floor tilts, and the octagon does not, a movement of the pitch action shaft is caused which opens either the climb or dive valve, depending on whether the Trainer is nosed up or down. Since the push pull connection from the pitch action shaft to the octagon is very nearly on the fore and aft center line of the Trainer, banking has no appreciable effect on the climb-dive valves.

It is necessary that the position, or movement, of the throttle also affects the "altitude" through the climb-dive valves.

This is accomplished by means of a "walking beam" on the bell crank of the pitch action shaft. A differential is thus provided between throttle movement or position, and nose up or down movement of the Trainer, and the resultant motion is transmitted to the climb-dive valves (Figure 9).

For example, if the Trainer is nosed up, the floor will be lowered at the point where the pitch action compensator extends down through to the octagon. This pushes the compensator upward through the floor and moves the arm "A", (Figure 9) upward. This rotates the pitch action shaft "B" carrying the top end of the walking beam "C" forward. Since the throttle was not touched, the walking beam is forced to pivot at point "D" where the throttle linkage connects. This swings the lower part of the walking beam in the other direction and pulls the climb valve open.

Suppose, instead of the Trainer being nosed up, the throttle had been opened. Pushing the throttle forward pushes the connecting linkage back at point "D". Since the pitch action shaft is stationary the walking beam is forced to pivot at point "E", again pulling the climb valve open.

If both motions are applied, that is, the throttle opened and the Trainer nosed up, the combined effect would open the climb valve further than in either previous example. But if the throttle is opened and the Trainer nosed down, the walking beam would pivot at point "F" while both "E" and "D" move in the same direction. This condition occurs when level flight (constant altitude) is maintained at full throttle. The amount that either climb or dive valve is open at any time, depends on the combination of throttle setting and the nose up or nose down attitude of the Trainer.

Indications of airspeed and engine speed are also a result of a combination of the setting of the throttle, and nose-up or nose-down attitude of the Trainer fuselage. The airspeed indicator and tachometer are vacuum operated instruments and the amount of vacuum supplied to each is controlled by a "Regulator Bellows". The action of the regulator bellows is in turn controlled by a mechanical linkage to the pitch-action walking beam in the same manner as the climb-dive valves. For example: When the Trainer is nosed up the pitch action causes the walking beam to pivot at point "D" (Figure 10), the top end going forward and the bottom end back, pulling the climb valve open. At the same time, as the top end of the walking beam moves forward, it pulls the link rods "L" (Figure 10) forward. This pulls the top end of levers "G" and "H" forward and swings their bottom ends back, slacking off on springs "S". As the spring tension is decreased the regulator will allow less vacuum to be applied to the indicators and the readings of the airspeed and tachometer will decrease. Due to the selection of the leverage ratios and regulating spring tension, the airspeed is affected much more by nose up or nose down movement of the Trainer than is the tachometer - while the throttle has an immediate, much greater effect on the tachometer than on the airspeed.

To introduce lag in the airspeed to simulate the rate of acceleration and deceleration of an airplane, a dampening tank is installed in the vacuum line between the regulating bellows and the airspeed indicator (See Figure 8). To avoid vacuum being trapped in the indicator when the regulator shuts off - which would prevent it returning to zero - a bleed hole is drilled in the airspeed dampening tank and in the line leading to tachometer. To further dampen and smooth out the action of the indicators, a restriction is used in the lines connecting to the airspeed and tachometer. This restriction is in the form of a small copper capillary tube with approximately a .018" inside diameter and is located at the point of connection to the instrument.

The Directional Gyro and Compass are regular aircraft instruments. The Turn and Bank is also a standard instrument except that the bank indicator is linked to the gimbal ring of the gyro. This was made necessary by the absence of centrifugal force in the Trainer. The Artificial Horizon is similar to an aircraft instrument except that it is a pendulous type.

L-174

PITCH ACTION & INSTRUMENT CONTROL SYSTEM SCHEMATIC

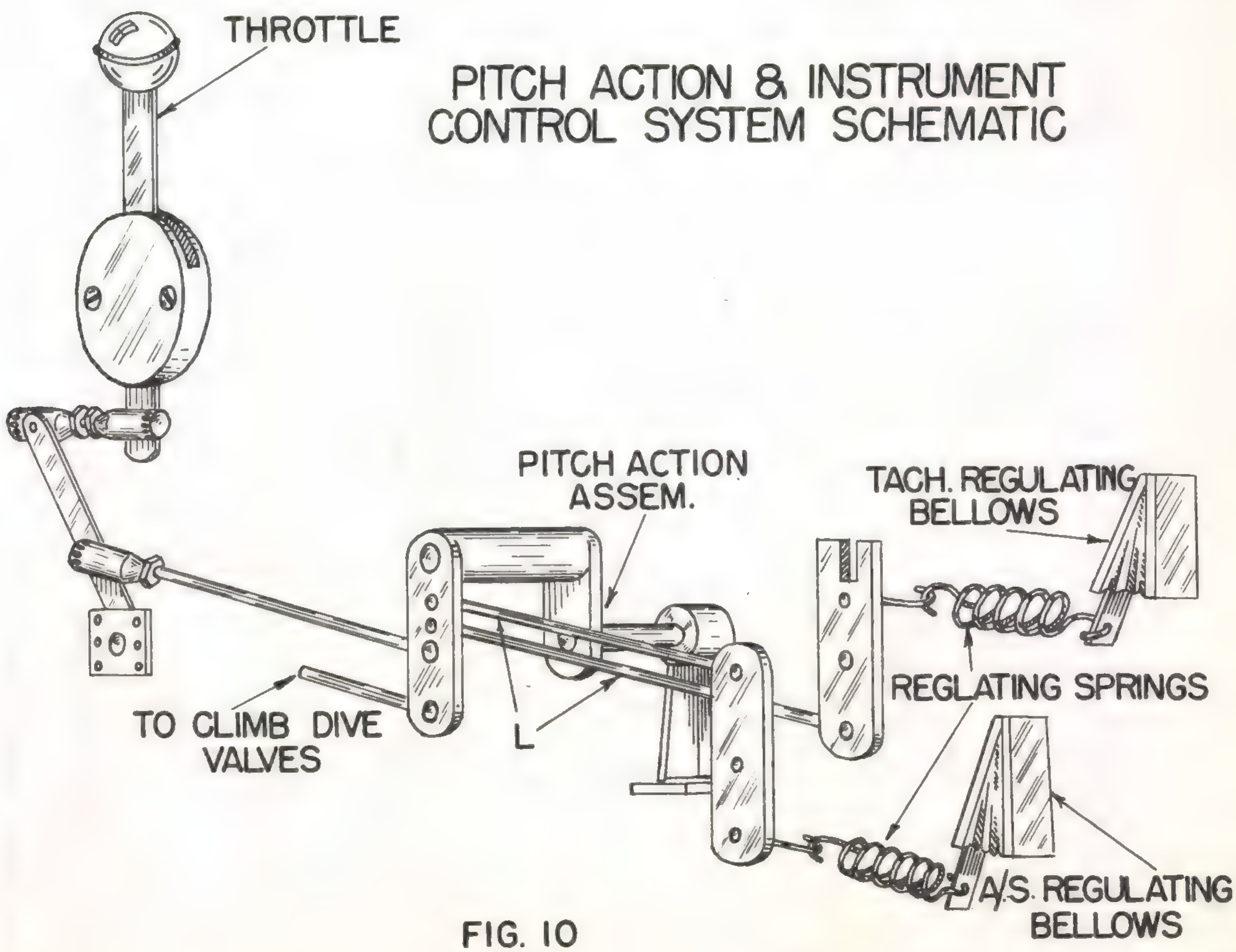
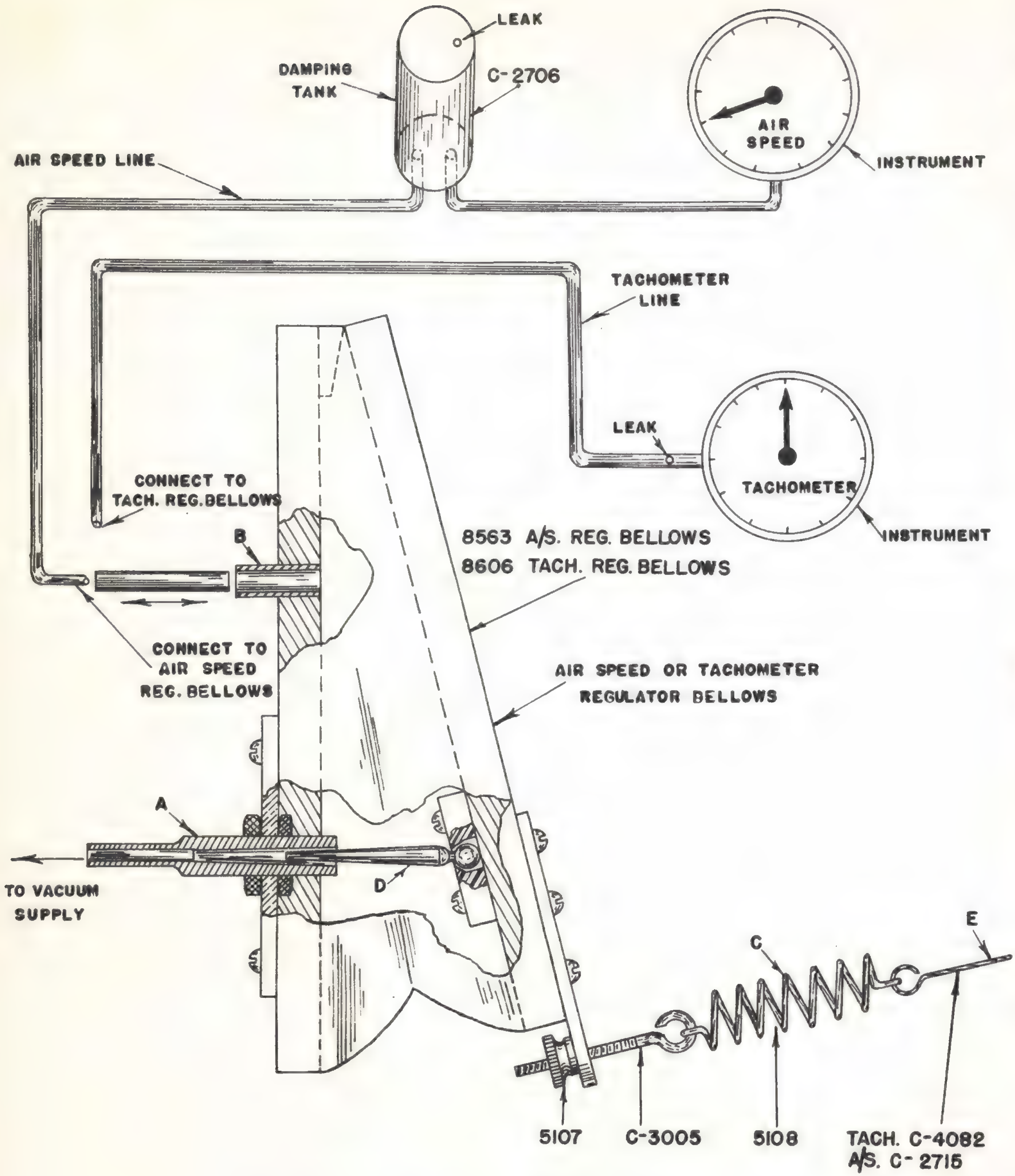


FIG. 10



AIR SPEED OR TACHOMETER
REGULATOR BELLOWS

FIG. - 11

AUG. 1, 1941

SECTION IV

REGULATING BELLOWS

Regulating Bellows (Figure 11) are used to control the amount of vacuum applied to the airspeed indicator and tachometer. These regulators are connected through coiled springs to the pitch action walking beam and so cause the effects of nose up or nose down attitude of the Trainer, combined with the throttle setting, to properly affect the two instruments.

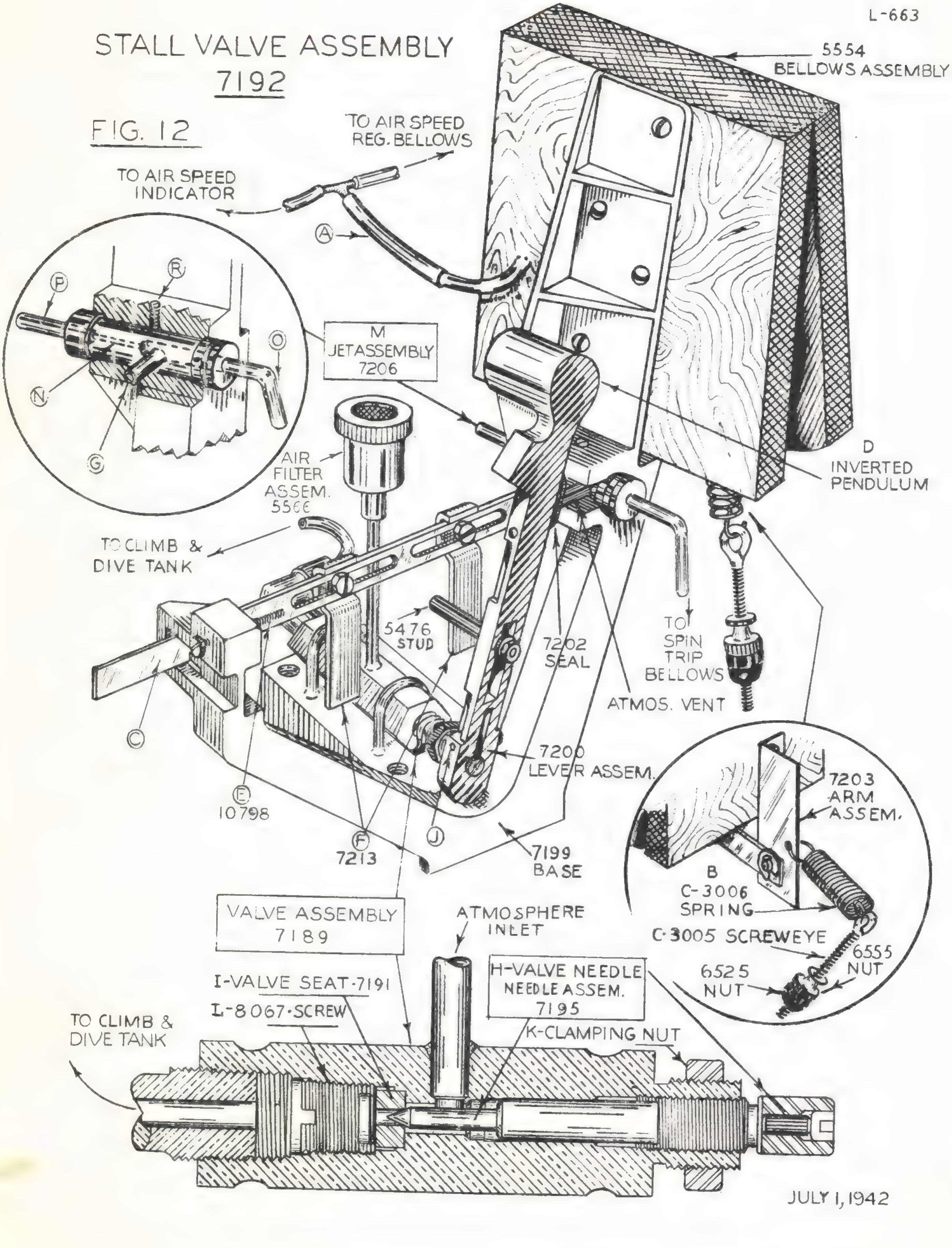
Fitting "A" (Figure 11) is connected by tubing directly to the main vacuum supply. "B" is connected by tubing through a small dampening tank (See Figure 8) to the airspeed indicator, or direct to the tachometer. (The bellows are the same for both instruments). When the Trainer is turned on and vacuum applied to the bellows at "A", air is drawn out and the bellows starts to collapse but the coiled spring "C" is tending to hold it open. Air continues to be drawn out until there is sufficient vacuum created to overcome the tension of the spring. As the spring is overcome, and the bellows closes, the needle valve "D" shuts off the supply of vacuum. The dampening tank in the tube to the airspeed has a small bleed hole (See Figure 8). As air leaks in through this hole the vacuum in the bellows decreases until it can be overcome by the spring, which then pulls the bellows open slightly. The needle valve will be opened only enough to permit the passage of just enough air to balance the leak in the dampening tank, and this condition will remain until the pull on spring "C" is changed. The "airspeed indicator" (or "tachometer") is simply a vacuum gauge and indicates the amount of vacuum inside the bellows.

Since the pull wire "E" is linked to the pitch action walking beam, any change in Trainer altitude or throttle setting will vary the pull of the spring "C" on the bellows.

If, by closing the throttle or nosing up, this spring is slacked off slightly, less vacuum will be needed in the bellows to overcome it. Consequently the airspeed (or tachometer) measuring this vacuum, will fall back to a lesser indication.

STALL VALVE ASSEMBLY 7192

FIG. 12



SECTION V

STALLING - STALL VALVE ASSEMBLY

(See Figure 12)

When the speed of an airplane drops below a certain minimum, the airplane "stalls" and sometimes starts to "spin". This characteristic is built into the Trainer and is a function of the "Stall Valve Assembly".

The bellows of this assembly is connected by tubing to the line leading from the airspeed regulating bellows to the airspeed indicator "A". Thus, the same amount of vacuum is applied to the stall valve bellows as to the airspeed indicator. At normal airspeed this vacuum is strong enough to keep the stall valve bellows closed (collapsed) and overcomes the tension of spring "B". In this position the inverted pendulum "D" rests against the stop screw "E".

At normal airspeed the pendulum "D" is being held against the stop screw "E" and atmosphere is continually entering the atmosphere vent "G" in the three-way jet assembly "M" between the line from the main vacuum supply and the line to the spin trip bellows. Due to the restriction "N" built into the vacuum side of this connection, the atmosphere entering vent "G" is sufficient to reduce the vacuum to the spin trip bellows line so that the spin trip bellows remains open.

As the airspeed is decreased, the vacuum in the stall bellows is correspondingly reduced. When it is reduced to a certain point, the spring tension is able to overcome the vacuum and pulls the stall bellows open. As the bellows opens, the rod "C" by means of the fingers "F" pulls the pendulum "D" back against the atmosphere opening "G". This closes the atmosphere vent "G", causing sufficient vacuum to be applied to the spin trip bellows to collapse it, causing the trainer to spin.

As the pendulum moves away from the stop screw "E", the needle "H" turns away from the valve seat "I", permitting a gradually increasing flow of atmosphere to pass through the valve into the "altitude" tank, gradually decreasing the vacuum in the tank, causing the altimeter and vertical speed indicator to indicate loss of altitude. The period from the time the needle valve starts to open until the actual stall and spin occur is known as the "mush" period, and is reflected on the altimeter and vertical speed indicator by loss of altitude indications.

SECTION VI

TURN WITH BANK, SPIN TRIP AND SPIN VALVE

These are functions of the "Spin-Trip Assembly". When the Trainer is banked, it will automatically turn in the direction of the low wing. This is accomplished by means of the rudder bar and banking attitude of the fuselage in much the same manner that the climb-dive valves are controlled.

For example: (See Figure 14). If the Trainer is banked to the left, the push-pull rod "A" will pull downward on arm "B" and rotate shaft "C". Since the rudder is not moved, the walking beam will pivot at "E" and exert a pull on compensator rod "F" which is connected to the rudder valve.

If the Trainer is not banked, the shaft "C" and bellcrank "D" will be stationary. Any movement of the rudder bar, connected to the walking beam at point "E", will cause the beam to pivot on the bellcrank at "G" and actuate the rudder valve.

Thus, the position of the rudder valve at any time is the result of the combination of the position of the rudder pedals and bar, and the lateral attitude of the Trainer.

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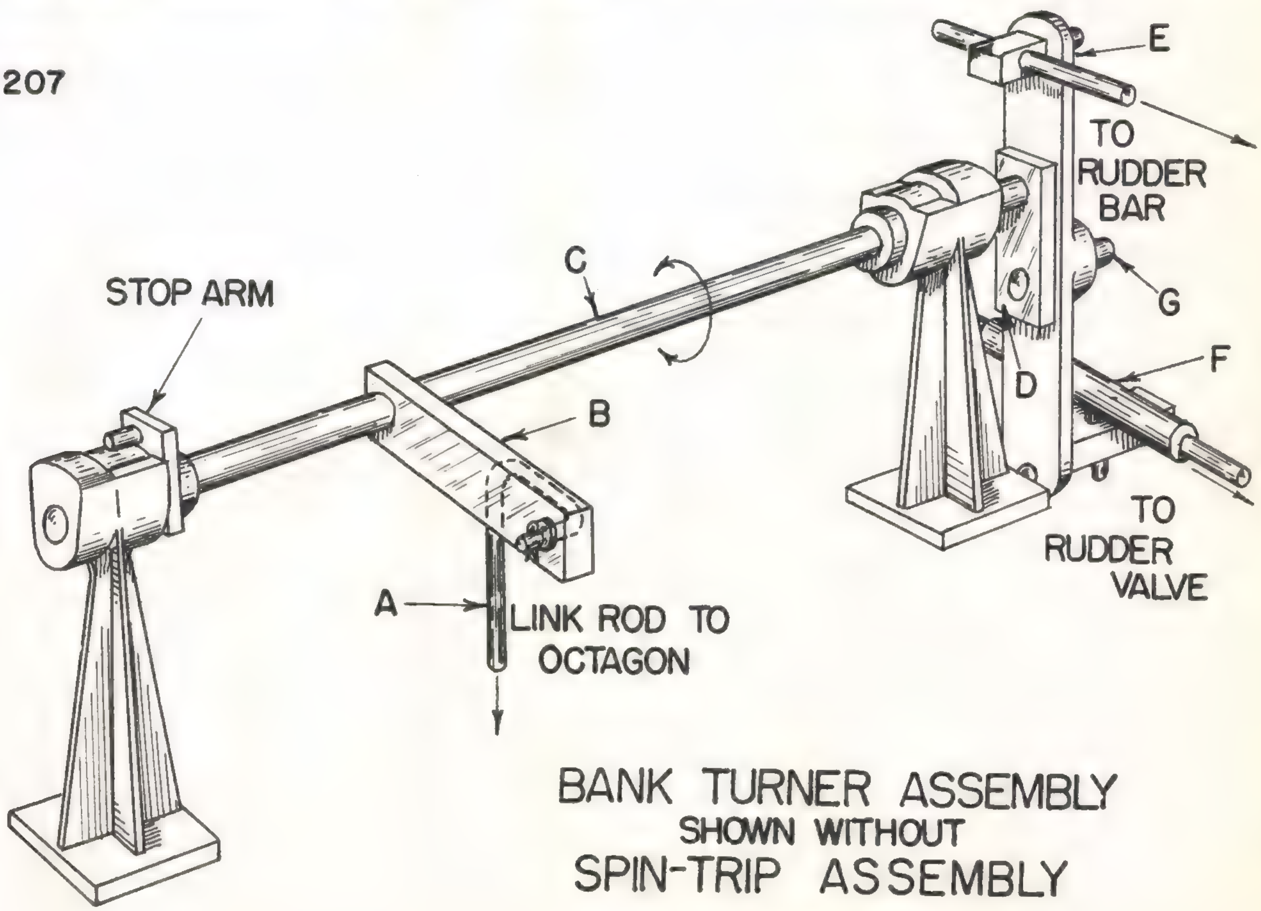
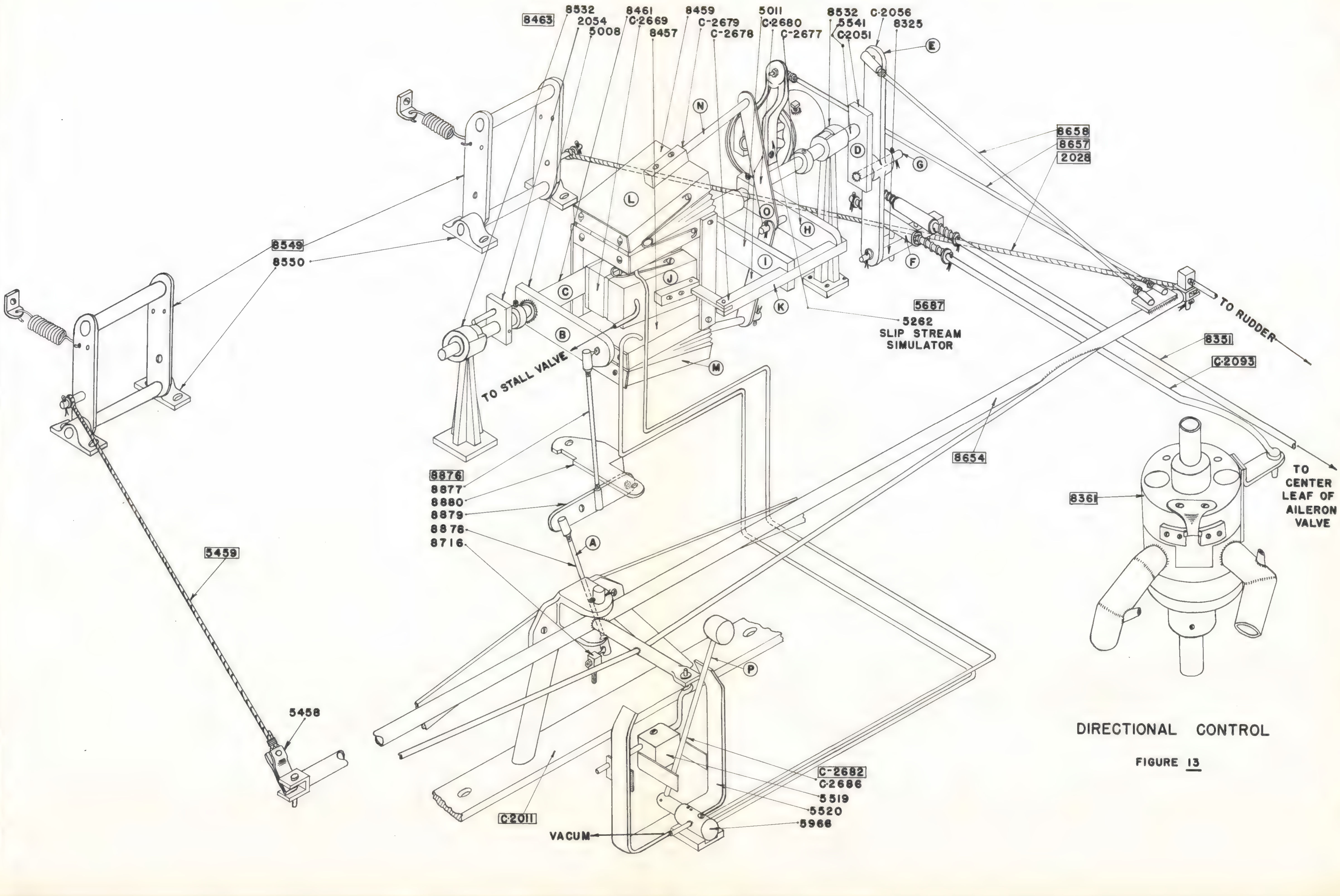


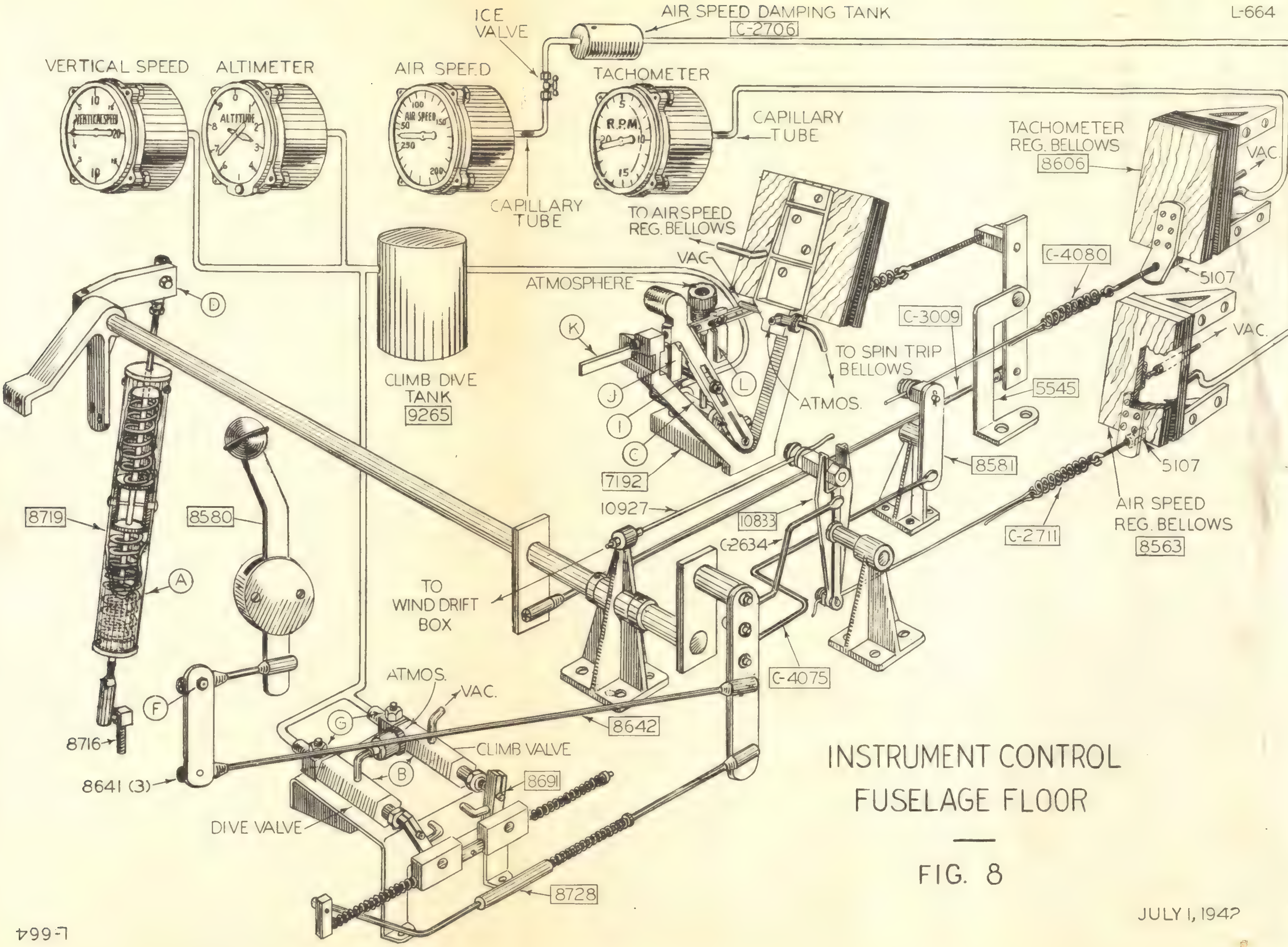
BANK TURNER ASSEMBLY
SHOWN WITHOUT
SPIN-TRIP ASSEMBLY

FIGURE 14



DIRECTIONAL CONTROL

FIGURE 13



INSTRUMENT CONTROL FUSELAGE FLOOR

FIG. 8

JULY 1, 1942

Automatic Spin

Automatic spin is accomplished by means of a bellows and latch assembly mounted on the automatic bank-turn shaft. (See Figure 13.) Three bellows are used - one to work the latch and the other two to provide energy for actuating the rudder valve when spinning.

These parts are mounted on a hollow shaft which is free to turn on the solid shaft of the bank-turner. Note in figure 13 that the arm "B", which is connected down through the fuselage floor to the octagon, is permanently attached to the hollow shaft on which bellows and latch are mounted. Arm "I" which carries the latch is also anchored to this hollow shaft. Note that arm "H" is secured by a set screw to the solid inner shaft. As long as the latch is engaged with arm "H" the solid shaft is locked to the hollow shaft and the entire unit functions only to provide the automatic turn-with-bank feature.

When the airspeed falls below stalling speed, the pendulum of the stall valve closes the atmosphere vent "G" (Figure 12), causing increased vacuum to be applied to the line that leads to the small bellows "J" which is linked to the latch "K". The vacuum closes this bellows and raises the latch out of the notch in arm "H". The hollow shaft is still held rigid by arm "B" but, with the latch disengaged, arm "H" and the inner shaft are free to turn.

Of the top and bottom bellows, one or the other is always under vacuum. Assume that at the moment vacuum is applied to the top one. This bellows, then, is trying to close and, when the latch releases arm "H", the following action takes place:

The bellows "L" closes. Through rod "N" and link "O" it pushes arm "H" down, rotating the solid inner shaft. The bellcrank on this shaft is swung forward and the walking beam, pivoting at point "E", pulls the rudder valve wide open, causing the Trainer to spin.

If the bottom bellows "M" had been under vacuum instead of the top one, the same action would have taken place, except in the opposite direction.

Spin Valve

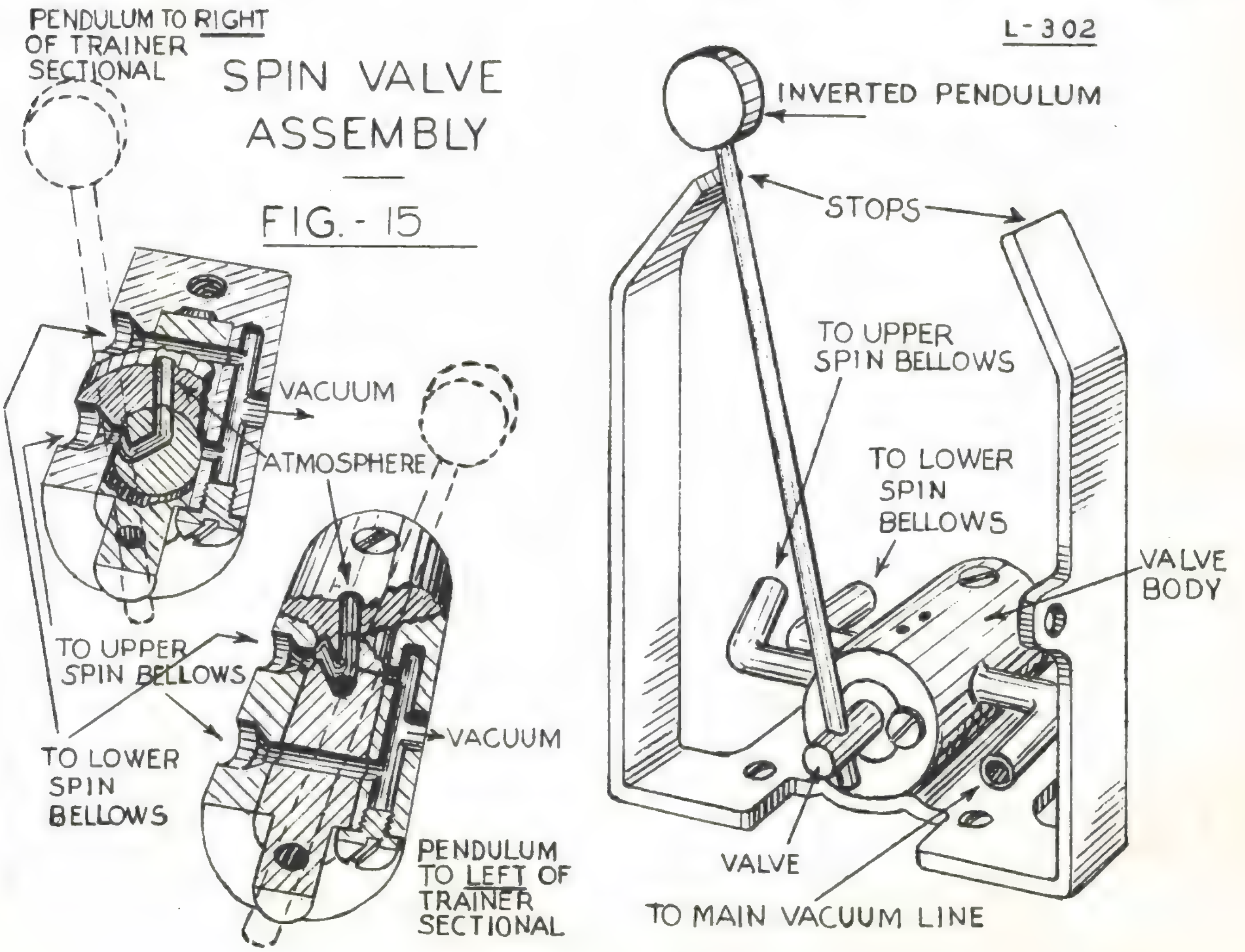
Control over which spin bellows shall be under vacuum is the function of the "spin valve" (Figure 15). This unit is simply a two-way valve which is connected on one side to the vacuum supply, and on the other to both spin bellows. It has an inverted pendulum and the position of this pendulum determines to which of the two bellows vacuum shall be applied. The pendulum normally falls toward the lowest side of the fuselage but, also can be thrown over by use of the rudder pedals, through a fork which extends back from the rudder bar. (See Figure 13.)

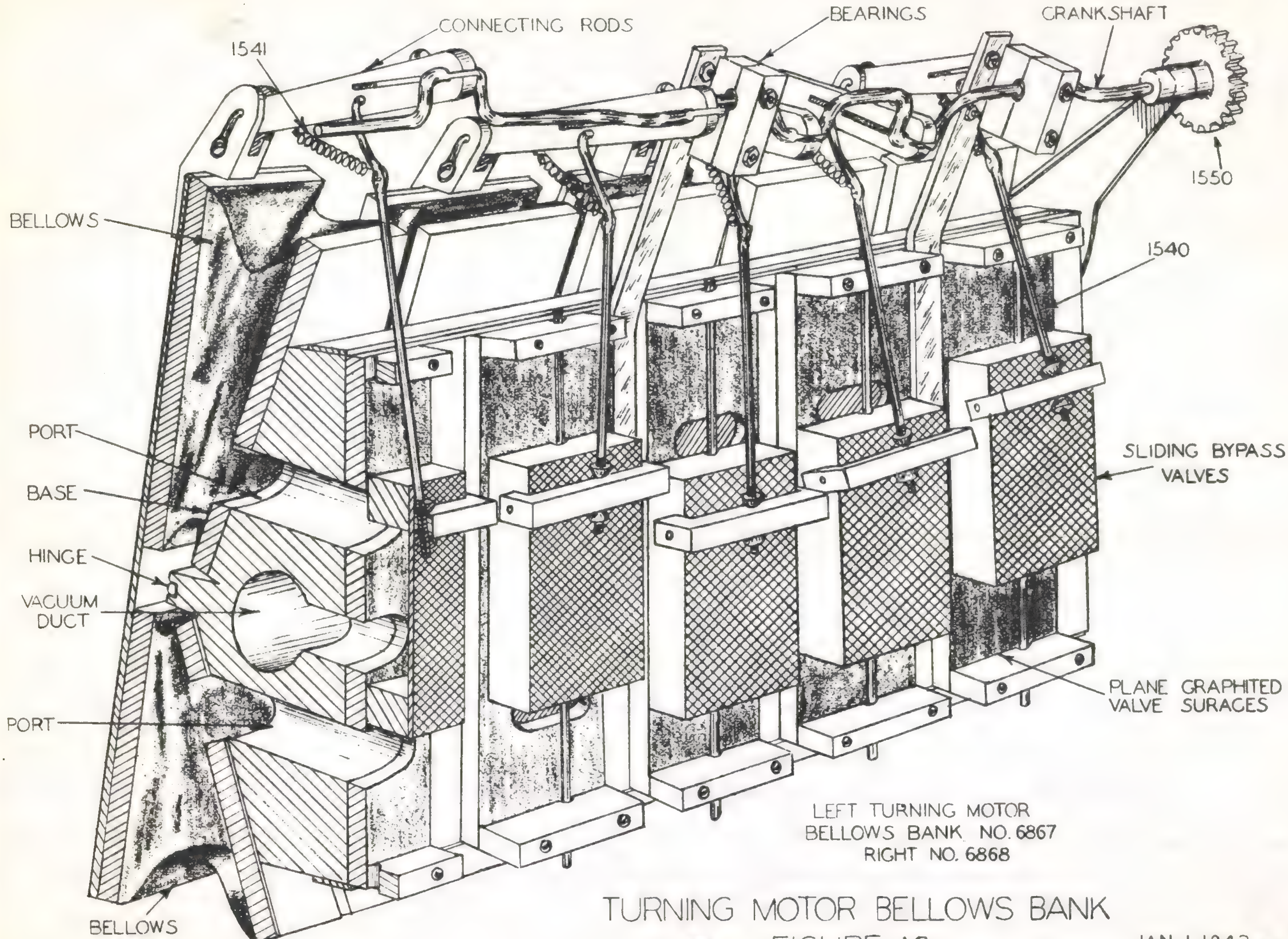
As long as the airspeed remains below "stalling" speed the small bellows controlling the spin trip latch will remain collapsed and the latch will remain raised where it cannot engage the notch in arm "H". During this time, full application of rudder will throw the spin valve pendulum over and apply vacuum to the other spin bellows. As this bellows collapses it will swing the arm "H" past the latch and move the rudder valve around to fully open in the opposite direction. This will reverse the direction of spin but normal rudder control cannot be regained until normal airspeed is recovered.

To recover from a spin in the Trainer, it is necessary to nose down - to regain normal airspeed - and apply full opposite rudder. When the normal airspeed is recovered, the pendulum of the stall valve moves away from atmosphere vent "G" (Figure 12), allowing atmosphere to enter, which decreases the vacuum to the small bellows. This bellows then expands (pulled open by springs) and returns the latch to its locking position. Full rudder is applied which throws the spin valve pendulum over. The opposite spin bellows starts to collapse, attempting to swing arm "H" past the latch. The latch, now being in its normal position, engages the notch in arm "H" and locks the solid shaft that carries the walking beam, restoring normal rudder control.

SPIN VALVE ASSEMBLY

FIG. - 15





LEFT TURNING MOTOR
BELLOWS BANK NO. 6867
RIGHT NO. 6868

TURNING MOTOR BELLOWS BANK
FIGURE-16

JAN. 1, 1942

SECTION VII

TURNING MOTOR, BELT AND BELT TIGHTENER

The air motor used for turning consists of two distinct motors, each with five double bellows connected to a crankshaft by connecting rods. (See Figure 16.) The crankshafts of both motors are geared to the same reduction gear unit terminating on a pulley for a round belt. Each motor is connected to the two-way air valve so that by applying right rudder, vacuum is allowed to enter one of the air motors causing the Trainer to turn to the right. Left rudder feeds the other motor and turns the Trainer to the left. While one motor is under vacuum, the other motor is idling, being connected to atmosphere through the two-way rudder valve. The bellows on these motors are constructed similar to the pitching and banking bellows, only smaller.

The connecting rods are made of hard wood impregnated with beeswax. The sliding valves are also of hard wood with graphite rubbed into the sliding surface.

Belt Tightener

The Belt Tightener consists of two idler pulleys mounted on slide rods (Figure 17) and are adjustable so that correct tension may be maintained on the turning motor belt.

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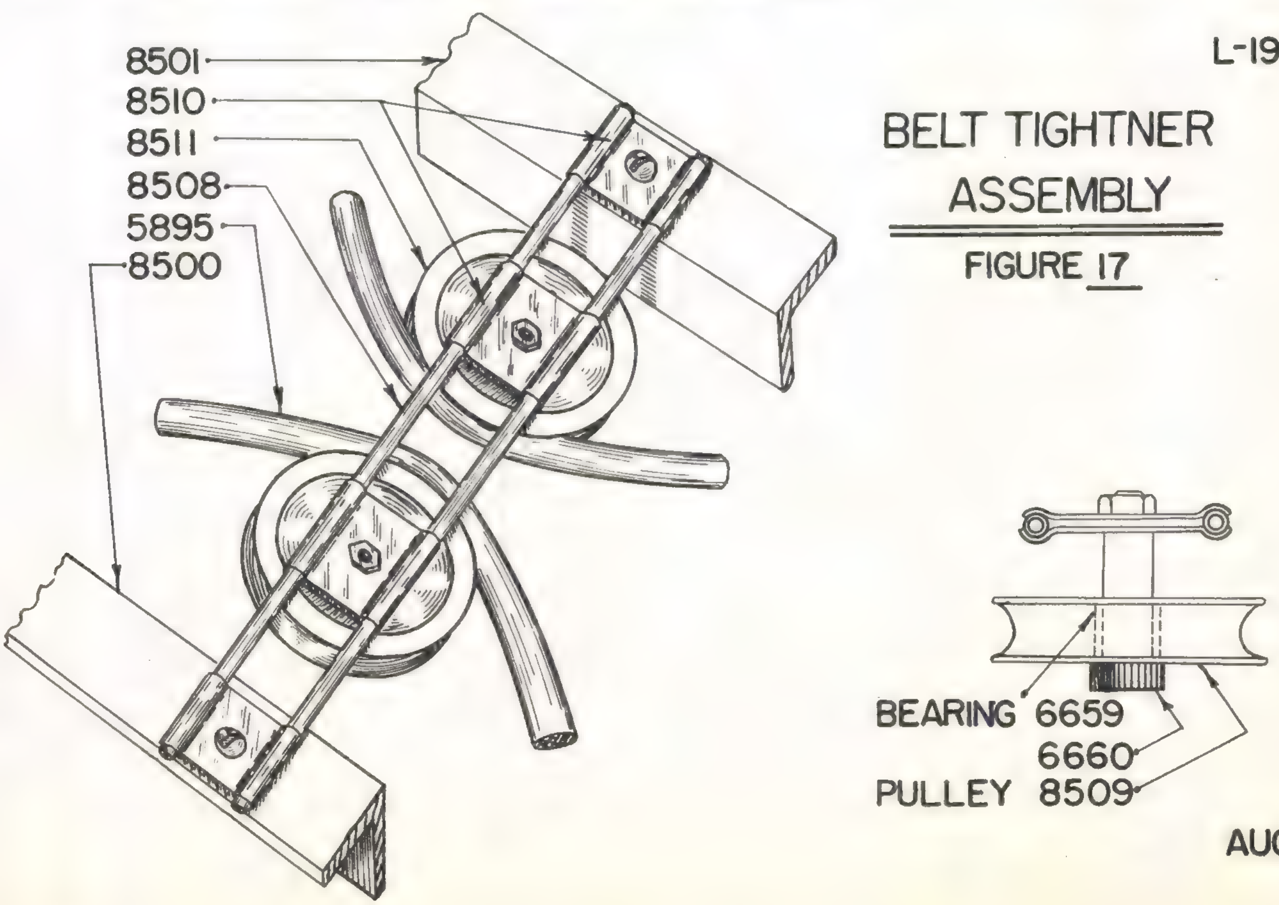

BELT TIGHTNER ASSEMBLY

FIGURE 17

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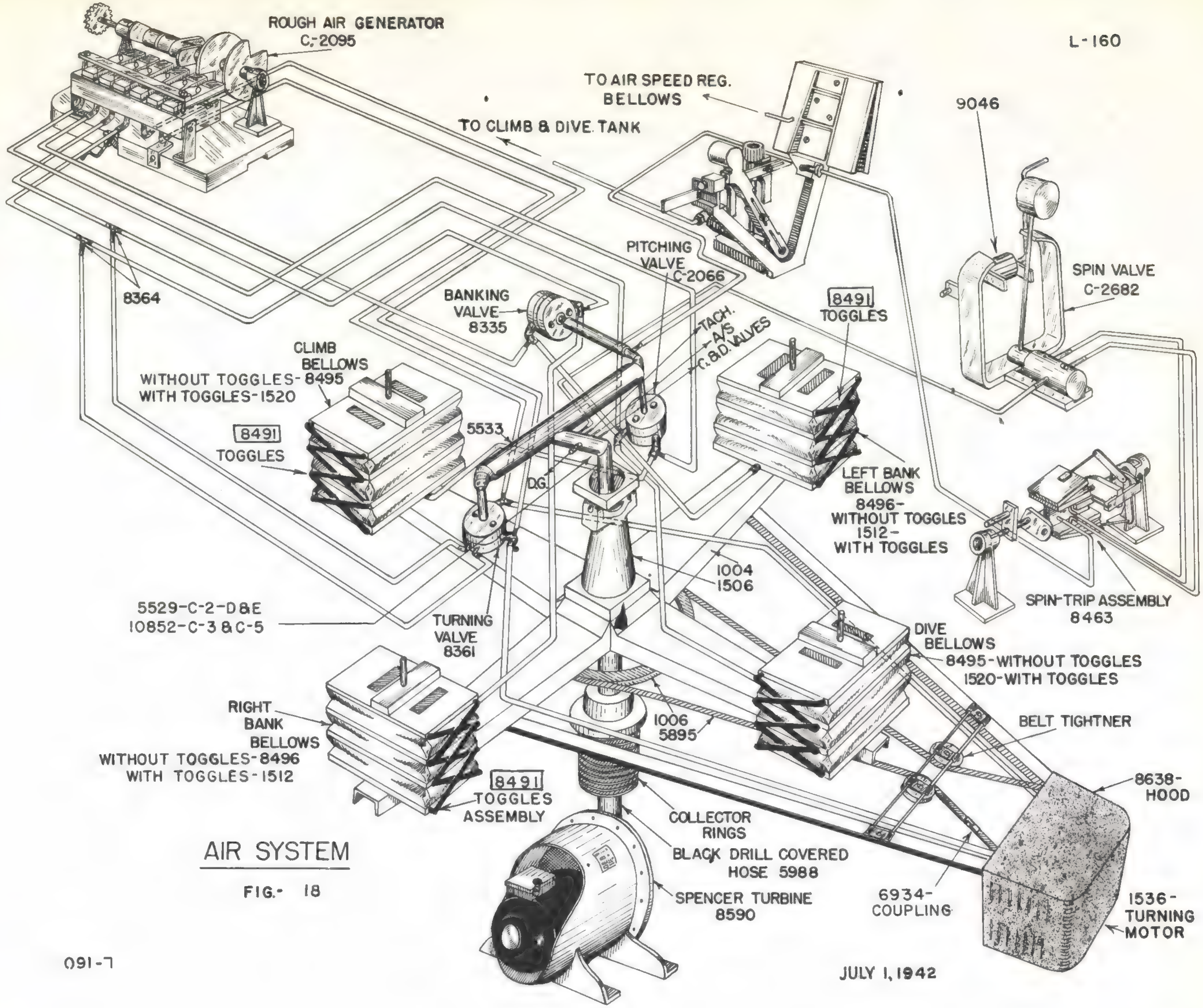


AIR SYSTEM

FIG.- 18

JULY 1, 1942

SECTION VIII

ROUGH AIR MECHANISM

System for Causing Bumps

This mechanism upsets the balance of air in various bellows by periodically opening cam-operated flap valves, actuated by the rear fan motor. The air system showing connection to these valves is shown in Figure 18.

When the Trainer is flying straight and level, both banking and both pitching bellows are pulling down equally. When one of the Rough Air flapper valves is opened by its cam, a leak is introduced in the main bellows to which the flapper valve is connected. This weakens the pull of that bellows and allows the opposite bellows to pull one side of the fuselage down. Thus, a lateral or a pitching bump occurs whenever the corresponding rough air flapper valve is opened.

Turning bumps are arrived at differently. Due to the overlap built into the rudder valve, a small amount of vacuum is constantly applied to the tubes leading to the turning motor. This vacuum is normally allowed to escape through two of the rough air flapper valves that are ordinarily held open. When one of these valves is allowed to close, the vacuum which has been escaping is applied to one bank of the turning motor, causing the Trainer to yaw.

The bumps are turned off by means of a crank located under the rear of the fuselage. Screwing out this crank allows the valves to lower so they will not make contact with the rotating cams. Under the two rudder-bump valves is a T-shaped push rod which holds these two valves off their seat when bumps are shut off. These valves should be held open 3/16 of an inch, thus permitting vacuum to escape when bumps are not desired and to produce smooth turning action of the Trainer.

SECTION IX

MAIN VALVES

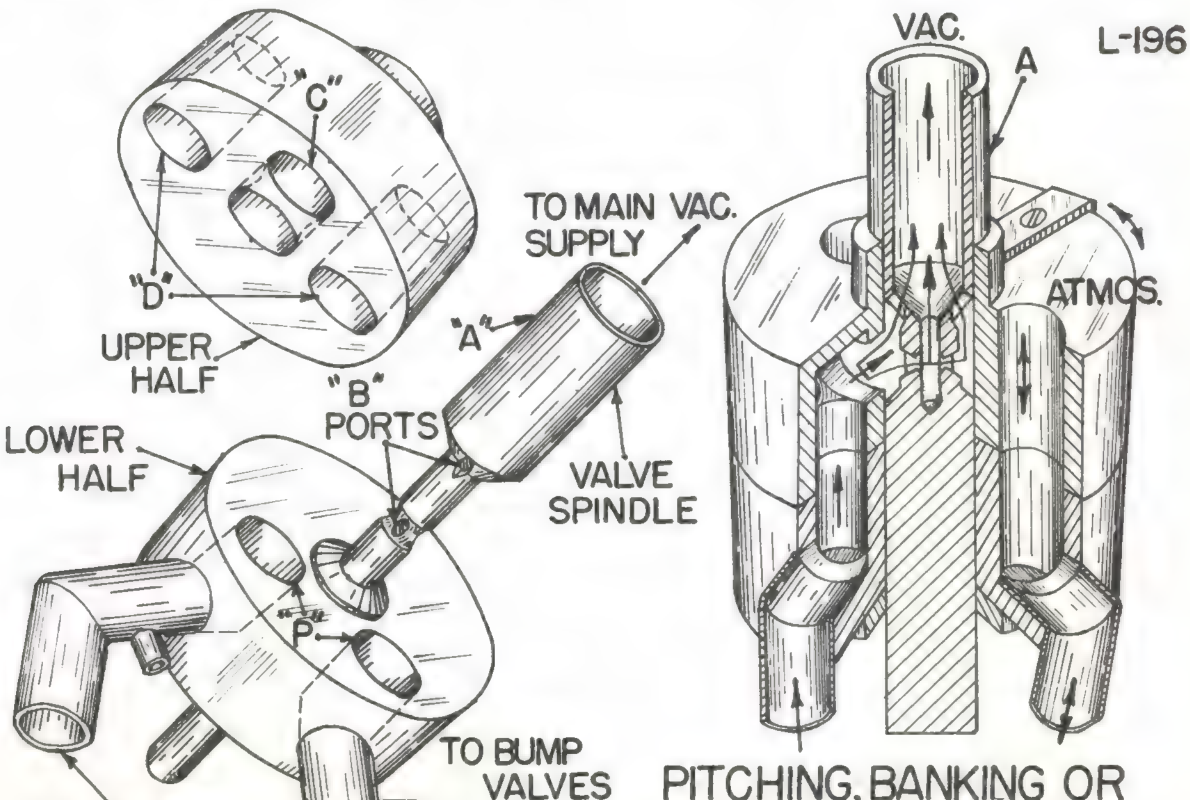
Rudder, Aileron, and Elevator

Three of these valves are used, all similar in design. Details of construction (Main Valves) are shown in Figure 19.

The suction supply is attached to tube "A" which is connected through the holes at "B" to port "C" in the top half of the valve. In the neutral position this port is between and slightly overlapping the two ports "P" in the lower half. In this position, due to the overlap, a small amount of vacuum is applied to both bellows attached to this valve, and both these bellows will be pulling downward equally. Movement of the wheel (or stick) rotates the top half of the valve, and moves port "C" over one of the ports in the lower half.

When one bellows is drawn closed, it is necessary to provide a way for air to get into the other. When the supply port "C" is moved over the bottom port leading to one bellows, one of the "exhaust" ports "D" is moved over the port leading to the other bellows, thus opening it to atmosphere.

Outlets "E" are part of the Rough Air System (See Chapter 2, Section 8.)

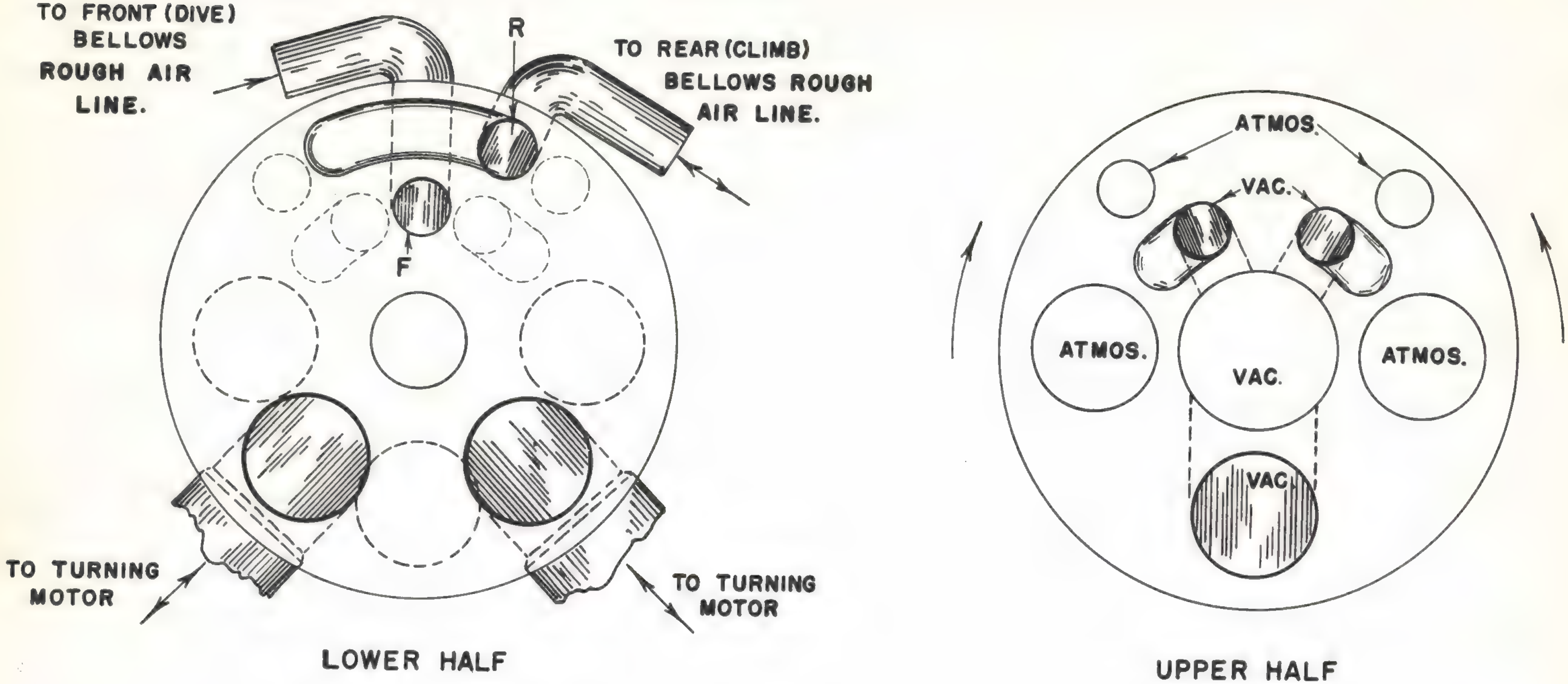


PITCHING, BANKING OR TURNING VALVE

FIG. 19

AUTOMATIC NOSE-DROP TYPE RUDDER VALVE

FIG. 19.1



PORTS SHOWN DOTTED, SHOW RELATIONSHIP OF UPPER HALF TO LOWER HALF, NEUTRAL POSITION

NOSE HEAVINESS DURING TURN

Most airplanes have a tendency to nose down during a turn. This tendency is reproduced mechanically in the Trainer by means of special ports in the Rudder Valve. Before reading further and attempting to understand this action, please refer to and study Chapter 2, Section 9, entitled "Main Valves". From that section, a clear understanding should be obtained of the functioning of the Rudder Valve. If Figure 19 and the accompanying section is understood, no difficulty will be encountered in understanding the nose down feature.

Referring to Figure 19.1, please note that this valve is similar to the valve shown in Figure 19. The left hand sketch is the bottom of the Valve, which is mounted in a socket fastened to the floor of the fuselage. The two large ports labeled "To Turning Motor" are the same as shown in Figure 19. The right hand sketch in Figure 19.1 is the upper half of the Rudder Valve, which is connected to the Rudder Pedals. On this sketch (right hand one), note that the four large ports are exactly the same as those shown in Figure 19. To obtain the "nose down" action, the additional ports shown in Figure 19.1 are added. In the left hand sketch (lower half) of the valve, note that one of the ports and its attached elbow leads to the front (Dive) bellows, and the other port and elbow lead to the rear (Climb) bellows. It will be seen from this that permitting vacuum to enter the port leading to the front bellows will pull the nose of the Trainer down. In order to permit this, it is necessary also to permit atmosphere to enter the rear bellows.

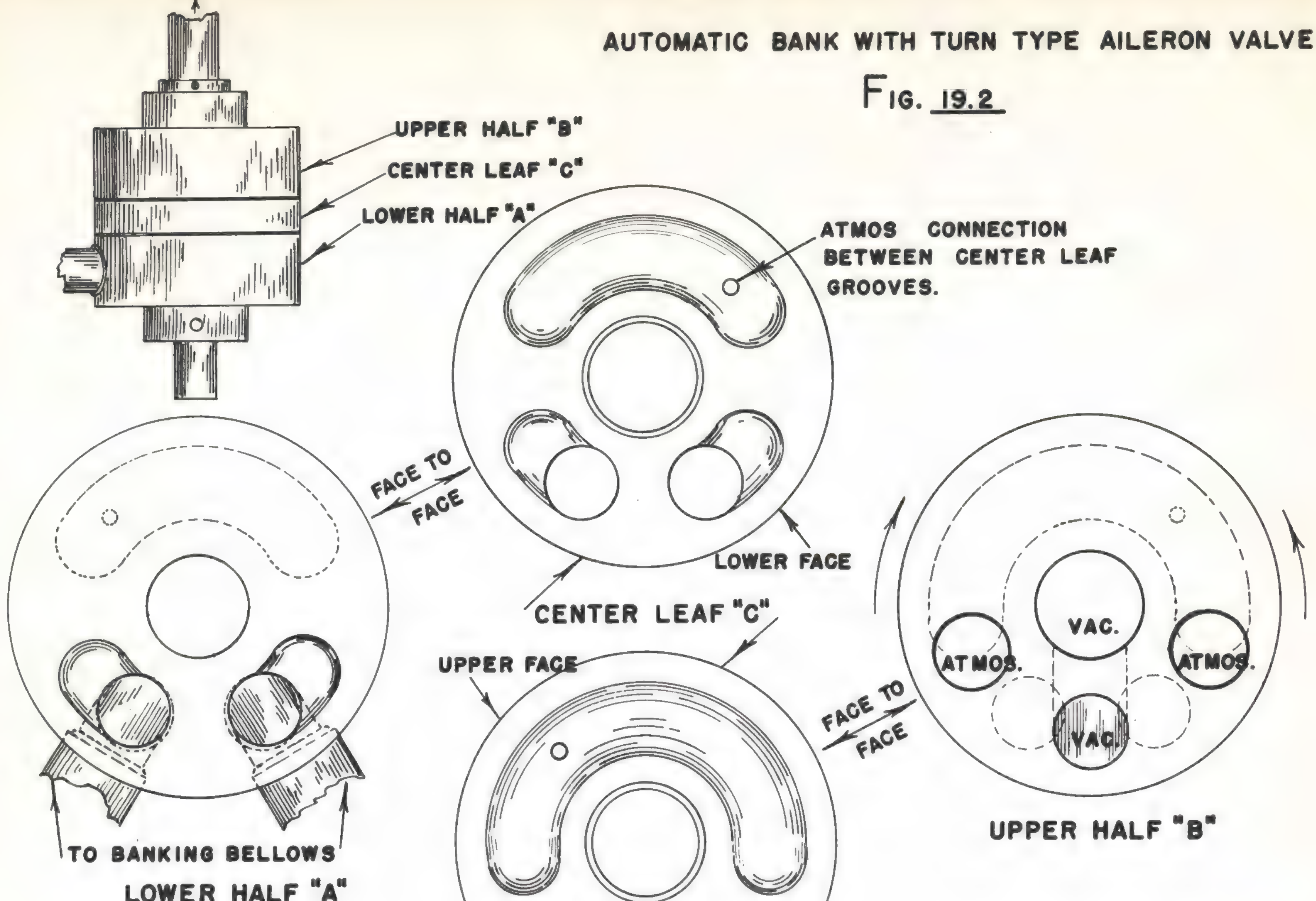
Referring again to that part of the sketch labeled "Upper Half", please note that there are two ports marked vacuum. When this "Upper Half" of the valve is in place on the "lower half", it will be seen that these two vacuum ports straddle the port marked "F" which leads to the front bellows. Consequently, application of the rudder in either direction will cause one of these vacuum ports to slide over the port leading to the front bellows. The remaining two small ports labeled "atmosphere" straddle the slot "R" which is cut in the lower half of the valve and which, as seen from the sketch, connects to the Rear Bellows.

Note that the two atmospheric ports are so placed that whenever Rudder is applied and the valve moved in either direction, one or the other of these two atmospheric ports is slid over the slot leading to the rear bellows.

It will be seen from the above that there is no provision for adjusting the amount of nose heaviness during turn. The proper proportion is arrived at in the design of the valve and the location of the holes.

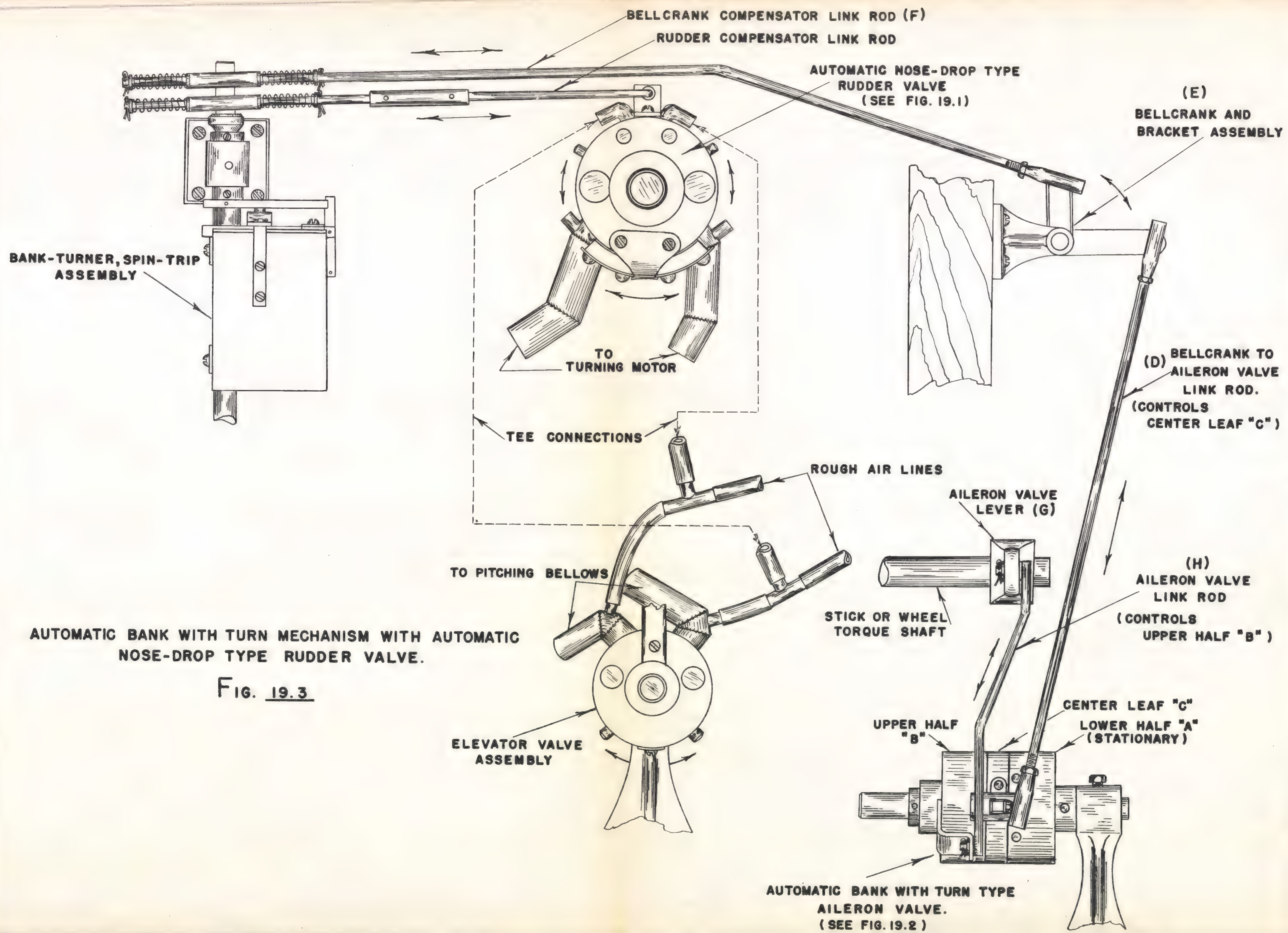
AUTOMATIC BANK WITH TURN TYPE AILERON VALVE

FIG. 19.2



DOTTED LINES SHOW RELATIONSHIP OF LOWER HALF TO LOWER FACE OF CENTER LEAF, NEUTRAL POSITION.

DOTTED LINES SHOW RELATIONSHIP OF UPPER HALF TO UPPER FACE OF CENTER LEAF, NEUTRAL POSITION.



AUTOMATIC BANK WITH TURN MECHANISM WITH AUTOMATIC NOSE-DROP TYPE RUDDER VALVE.

FIG. 19.3

AUTOMATIC BANK WITH TURN

Nearly all airplanes will automatically bank to some extent whenever rudder is applied, without the aid of the Ailerons. This is obtained in the Trainer by means of interconnecting the Aileron Valve with the rudder action.

The Aileron Valve is practically the same as the main valve shown in Figure 19, Chapter 2, Section 9. A complete understanding of this valve should be obtained before attempting to understand the Automatic Bank feature. It will be noted in the study of Figure 19 and its accompanying text, that control of vacuum is obtained by moving or rotating the upper half of the valve. A little thought will show that by holding the upper half of this valve stationary and rotating the lower half, the same result would be accomplished. Since it is not possible to rotate the lower half due to hose connections, etc., a third part was added (see Figure 19.2). This third part ("C") consists of a center leaf between the upper and lower halves. The ports (holes) in this middle portion of the valve coincide exactly with those in the bottom or fixed portion of the valve ("A"). Consequently when this middle portion ("C") is rotated, the effect is exactly the same as would be obtained by rotating the lower half of the valve as shown in Figure 19. Please note that the ports in the middle leaf ("C") are countersunk on the side which faces the bottom or fixed portion of the valve. This is done so that movement of the middle leaf will not hamper the flow of vacuum thru the bottom or fixed portion of the valve. With this middle portion of the valve stationary, movement of the upper part of the valve ("B"), (which is connected to the aileron control), results in the same action as would have been obtained without the middle leaf as mentioned above. The upper half of this valve ("B") is directly connected by linkage to the control column so that it is actuated by sideward motion of the stick or wheel.

The middle leaf ("C") is connected by linkage to the Rudder Pedals. Consequently, when the Ailerons are applied, the upper half of the valve is rotated causing the Trainer to bank. If the Ailerons are left in neutral and rudder applied, the center leaf rotates, thus also causing the Trainer to Bank.

SECTION X

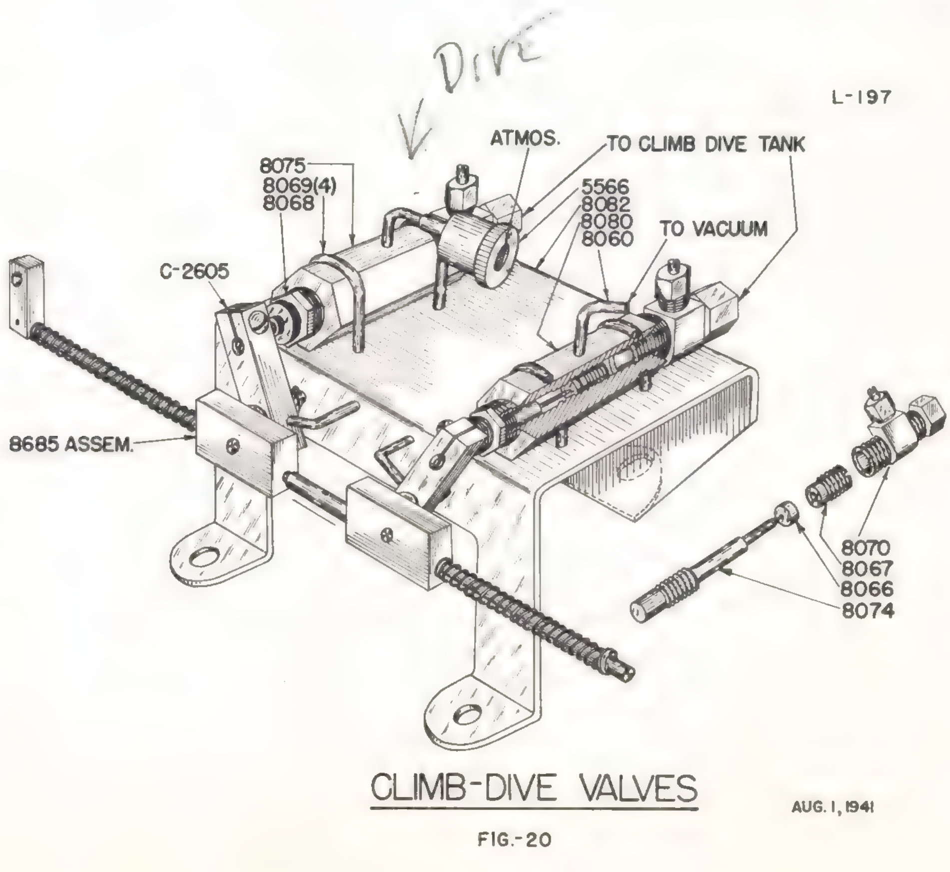
CLIMB-DIVE VALVES

The Climb-Dive Valve Assembly consists of two separate valves mounted and controlled as a unit. (Figure 20) In the neutral, center (cruising) position both valves are closed. Movement of the throttle or change in the nose up or down attitude of the Trainer will open either one valve or the other. When one valve opens, the other remains closed.

One valve (climb valve) of the pair controls the vacuum applied to the climb-dive, or "altitude" tank, and the other valve (dive valve) controls the air permitted to flow back into the tank. The dive valve is equipped with an air filter to exclude dirt, which might clog the needle.

The valve needle is an assembly composed of two parts, the needle proper and a sleeve into which the needle is silver-soldered. The needle has a small diameter for a portion of its length, to give it flexibility, and is self-centering in the valve seat. The needle sleeve is threaded and screws into the brass body of the valve. A clamp nut is provided to take up wear in these threads.

Adjustment of these valves is an exceedingly delicate operation and should be attempted only by a factory trained man or an authorized repair base.



CLIMB-DIVE VALVES

FIG.-20

FLIGHT LOG (AUTOMATIC RECORDER)

The Flight Log travels over the chart or map on three wheels. Two of these wheels are drivers and the third is an inking wheel, which leaves an inked track on the chart. Two synchronous telechron motors are geared to the driving wheels and provide forward travel of the recorder. With the aid of a shifting device, the drive gears of the motors can be shifted from a low speed to a high speed. The low speed gears are used for ordinary instrument and radio orientation problems, while the high speed gear drive is used for instrument landing problems. It is possible to change from the low speed gearing to the high speed gearing without removing the motors. To do this, merely shift the large gear (A), as shown in Figure 20.1 to engage with the smaller driving gears (B). The wheels, when in position "C" drive the recorder at the rate of .845 inches per minute at cruising speed. To change the speed of the recorder, merely shift the gear by pulling the large driving gear away from the bracket "D" to engage the other set of small driving gears. With the gear as shown in position "E", the recorder now travels at the rate of 3.38 inches per minute at cruising speed.

When shifting the gears, make sure that both gears are engaged, as there is a neutral position between each gear ratio. Be sure both motors are set to the same tracking speed. Otherwise, the recorder will not track properly.

Directional control is obtained with a Teletorque (Selsyn type) motor, located in the center of the Flight Log (Figure 5.1). Each of the three wheels is attached to a vertical shaft. At the top of each shaft is a large gear. All three of these large gears mesh with the small pinion gear on the Teletorque motor (Figure 5.1). Thus when the Teletorque motor is caused to rotate, the three large gears and their shafts also rotate and steer all three wheels. It will be seen from this that the three wheels should always be headed in the same direction.

A similar Teletorque motor is located in the Trainer base (Figures 3 and 5.1) and geared to the vertical main shaft of the Trainer. It is a characteristic of the Teletorque motor that when the one in the base is rotated (by the Trainer turning), the Teletorque in the Recorder duplicates the turn. This steers the Recorder and causes it to faithfully trace on the chart the turns made by the student. A detailed description of Teletorque and Telechron motors will be found in Chapter 4, Section 8.

When the Trainer main switch is turned on, the Teletorque motors "come alive" and line up with each other. Since the one in the base is geared to the main spindle and so cannot move unless

the Trainer is turned, the one in the Flight Log rotates and lines itself up with the one in the base. Between the Teletorque pinion gear and the large gears in the Recorder, there is a gear ratio of 12 to 1. Consequently, when the Teletorques "come alive" and line up with each other, the Recorder will jump to the nearest any one of 12 headings. If the Flight Log is properly synchronized, as described in Chapter 1, Section 7, it will only be necessary at the start of each problem to spin the large gears around by hand until the inking wheel is headed the same direction on the map as the Trainer fuselage is headed by compass. The Trainer heading is shown by the cards on the octagon.

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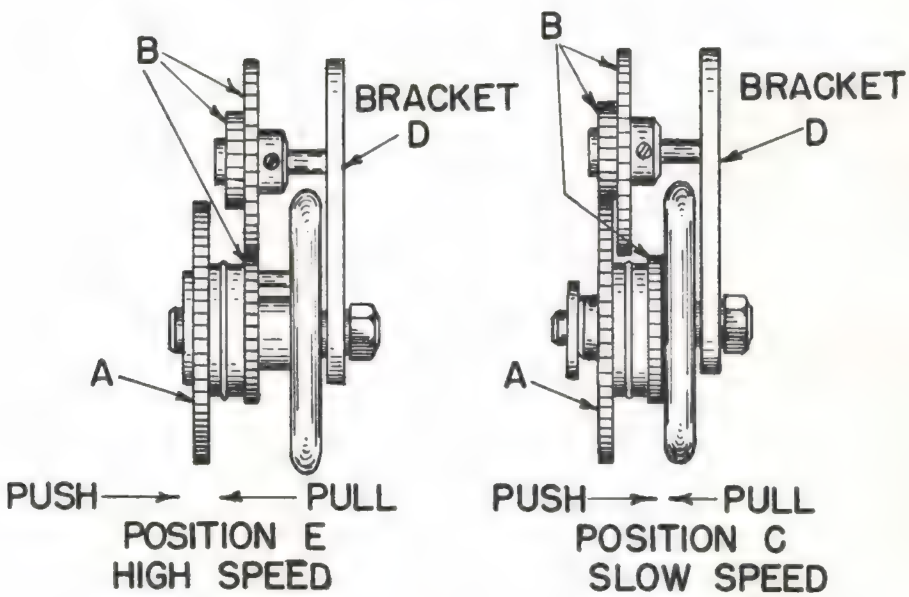


GEAR
SHIFTING
DEVICE

FIGURE 20.1

SECTION XII

MAIN (BANKING & PITCHING) BELLOWS

The banking and pitching bellows are made of four pieces of wood (top, two middle sections and bottom) and are covered with rubberized fabric (Figure 3). Four of these bellows are used with the bottoms fastened to the revolving platform and the tops fastened through a linkage to the bottom of the Trainer fuselage. Two of the bellows are for banking and two for pitching. Several holes are in the top of each bellows covered by a flap so that if a bellows is pushed together when no vacuum is being applied, the air can escape and damage is prevented. These flaps are stretched tightly over the holes forming an air tight escape valve.

VACUUM TURBINE AND AIR TRANSFER

Vacuum Turbine

The vacuum turbine requires very little attention as there are only two ball bearings to lubricate at the end of each 100 hours of operation. The three-quarter horsepower electric motor connected directly to the turbine requires only the normal attention any electric motor should receive. (See Chapter 5, Section 6.)

Air System

Due to the turbine being located in the base of the Trainer and the Trainer rotating around the base, it is necessary to have a sliding or rotating valve to take the air up through the base to the Trainer valves. Figure 3 shows a cross-section of the main air system. A large rubber hose passes through the center of the hollow shaft and universal joint. The lower end of this hose connects to a steel sleeve and cast iron elbow bushing which is fitted closely and forms an air tight rotating joint. On the floor of the fuselage, the upper end of the hose connects to an elbow which in turn connects to a main distributing manifold. (See Figure 18.)

FIG.-44

LINK TRAINER LUBRICATION CHART

WARNING
EXCESS OIL WILL CAUSE DAMAGE

SECTION	HOURS	PART NAME	NO. PLACES	LOCATION	LUBRICANT	REFERENCE
FUSELAGE	As Needed	Artificial Horizon Dash Pots	2	Instrument Panel	Castor Oil	Fig. 26
	500	Artificial Horizon	6	Instrument Panel	Gun Oil	Fig. 26
	50	Climb-Dive Valves Assembly	Ext	Fuselage Floor - Left Side Center	Gun Oil	Fig. 20
	50	Stall Valve Assembly	Ext	Fuselage Left Side - Floor	Heavy Oil	Fig. 12
	50	Ventilator Fan (Front)	2	Fuselage - Front Panel	Gun Oil	
	500	Spin Valve Assembly	1	Fuselage Floor - Rear	Heavy Oil	Fig. 15
	50	Climb-Dive Compensator Springs	2	Mounted on Climb-Dive Valves Assembly	Gun Oil	Fig. 20
	50	Control Wheel Rear Bracket	1	Mounted on Fuselage Seatback Sup.	Heavy Oil	
	50	Control Wheel Front Bracket	1	Fuselage Floor - Center	Heavy Oil	
	50	Leverage System	23	Fuselage Floor - Center	Gun Oil	Fig. 8
	50	Pitch Action Shaft Brackets	2	Fuselage Floor - Left and Right	Gun Oil	Fig. 9
	As Needed	Slip Stream Simulators (Oleo) Inside	3	Fuselage Floor - Center and Right	#500 Houde	Fig. 21
	50	Slip Stream Simulator Fittings	9	Fuselage Floor - Center and Right	Gun Oil	Fig. 13-24
	50	Control Wheel Eccentric Bushing, Gear, Balljoints	3	Control Wheel Column (Top and Bottom)	Gun Oil	Fig. 24
	50	Aileron & Rudder Valve Compensator Springs	2	Fuselage Floor - Right Side & Rear	Gun Oil	Fig. 13
	50	Vibrator Motors	2	Rear of Inst. Panel & Transmitter Panel	Gun Oil	Fig. 47
	50	Rough Air Shaft Bearings & Crank	3	Fuselage Floor - Rear	Gun Oil	Fig. 7
	50	Stall Valve Stops & Slide Hole	3	Stall Valve - Top	Gun Oil	Fig. 12
	50	Bellows Hook-up Sockets	4	Fuselage Floor - Left, Right, Front & Rear	Heavy Oil	Fig. 3
	50	Rudder Pedals	6	Fuselage Floor - Front	Heavy Oil	Fig. 13
	50	Rudder Bar	4	Fuselage Floor - Center-Right	Heavy Oil	Fig. 13
	50	Bank Turner Spin-Trip Assembly	9	Fuselage Floor - Center	Heavy Oil	Fig. 14
	50	Control Stick, Shaft and Connections	9	Fuselage Floor - Center	Heavy Oil	Fig. 24
	500	Compensator Springs	7	Between Fuselage Floor & Octagon	Heavy Oil	Fig. 9
	50	Rough Air Gears	1	Fuselage Floor - Rear	Heavy Grease	Fig. 7
	50	Rough Air Fan Motor	1	Fuselage Floor - Rear	Heavy Grease	
	50	Rudder Valve	1	Fuselage Floor - Right Rear	Gun Oil	Fig. 13
	50	Elevator Valve	1	Fuselage Floor - Left Rear	Gun Oil	Fig. 18
	50	Aileron Valve	1	Fuselage Side - Left Rear	Gun Oil	Fig. 18
OCTAGON	50	Main Universal Joint	4	Trainer Octagon - Center	Grease	Fig. 3
	50	Universal Studs	2	Trainer Octagon - Cross	Heavy Oil	Fig. 13
	50	Turning Motor Gears	2	Turning Motor Assembly	Heavy Grease	Fig. 16
	50	Turning Motor Slide Valves	10	Turning Motor Bellows Bank	Graphite	Fig. 16
	Sealed	Turning Motor Ball Bearings	-----	Turning Motor Assembly	Sealed	
	50	Belt Tightener Assembly	2	Trainer Octagon Arms - Front	Heavy Oil	Fig. 17
BASE	100	Turbine and Motor Unit	2	Trainer Base - Bottom	Heavy Grease	Fig. 3
	100	Transfer Elbow	1	Trainer Base - Bottom of Collector Ring	Heavy Oil	Fig. 3
	1000	Main Housing Ball Bearings	2	Trainer Base - On Cross	Medium Grease	Fig. 3
	Dry	Pick-Up Assembly Gear	2	Trainer Base - Center	Dry	Fig. 5
EMPENNAGE	100	Rudder and Controls	4	Fuselage Empennage - Rear	Heavy Oil	
	100	Elevator and Controls	5	Fuselage Empennage - Rear	Heavy Oil	
WINGS	100	Aileron and Controls	14	Left and Right Trainer Wings	Heavy Oil	
	100	Aileron Hinges	4	Left and Right Wings - Top	Gun Oil	
	100	Bell Crank Post	2	Left and Right Wings - Underneath	Gun Oil	
DESK	50	Automatic Recorder Drive Gears	-----	Automatic Recorder Unit - Desk	Light Oil	Fig. 5
	50	Radio Range Keyer	10	Radio Desk Drawer	Gun Oil	Fig. 29
	50	Vibrator Motor	2	Remote Inst. Case Panel	Gun Oil	Fig. 47

SECTION XIII

SLIPSTREAM SIMULATORS

These units are designed to stiffen, or load, the elevator aileron and rudder control.

The body of the unit contains vanes on the large shaft which operate in fluid-filled compartments. The fluid flows from one side of each vane to the other side through a controllable valve which can be adjusted to furnish the desired resistance, or stiffness of elevator or rudder control. Protruding from the unit is a large shaft to which a lever arm is clamped. The adjustment is located in the end of this shaft in the form of a rectangular "head" or "nut" with an ear on one side bent over to form a pointer (Figure 21).

The hex nut, between the adjustment and lever arm, holds in place a packing to prevent leakage around the valve shaft.

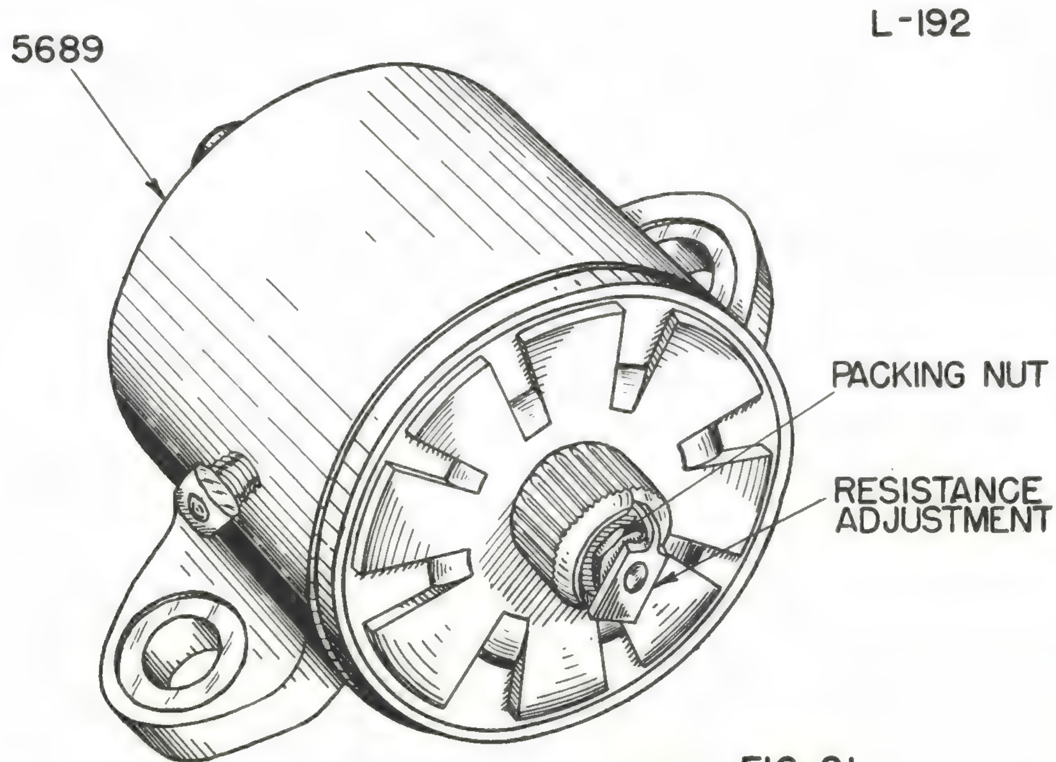
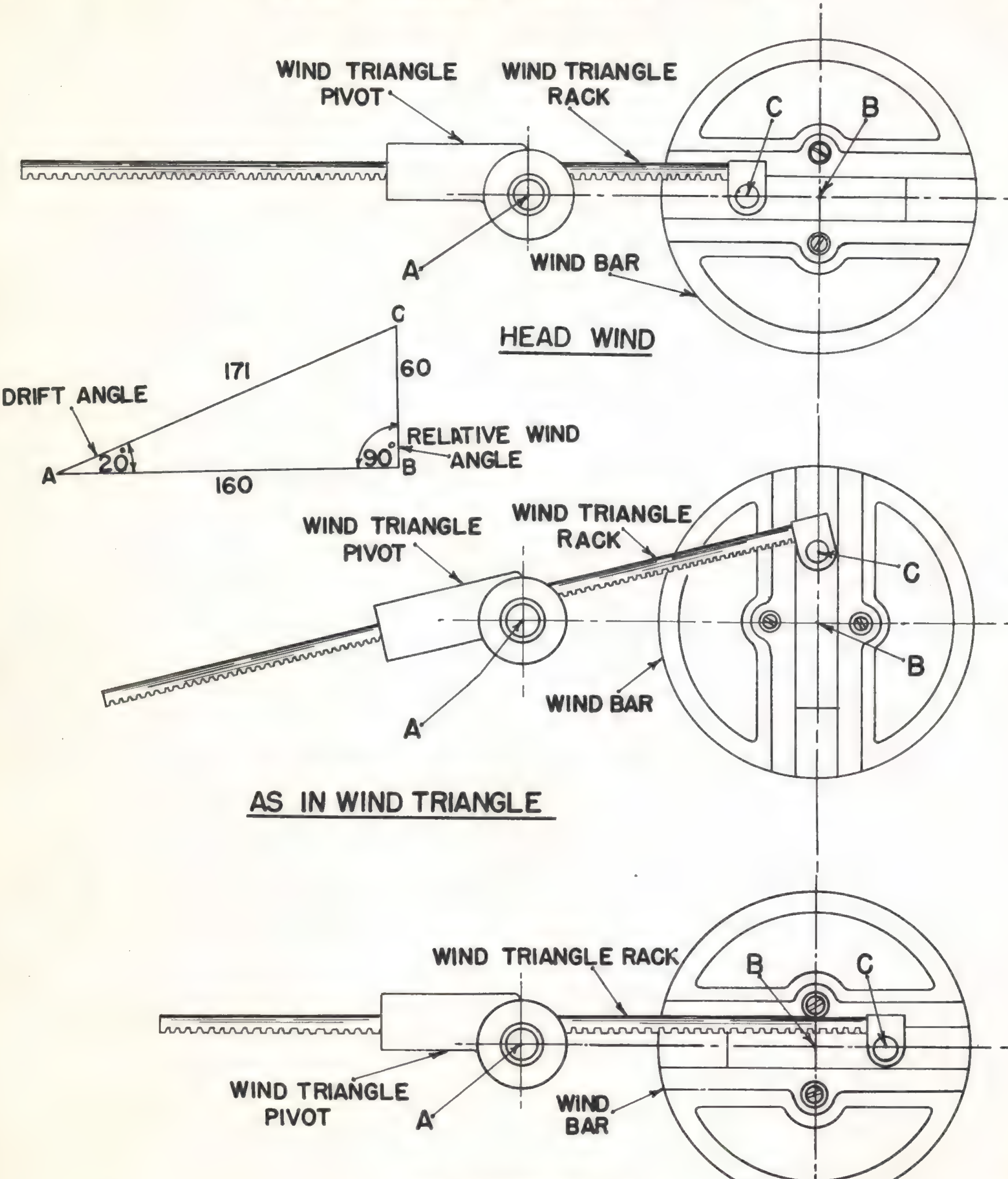


FIG. 21

WIND DRIFT MECHANISM

WIND TRIANGLE POSITIONS



TAIL WIND FIG. 22

WIND DRIFT MECHANISM

The Wind Drift Mechanism serves to introduce the effect of various wind directions and velocities on Trainer heading and ground speed at cruising and other airspeeds, as traced by the Recorder.

In order that the pilot working in the Trainer may be subject to the same conditions as he would be in the air, it is necessary to provide simulated wind conditions. These conditions appear in the behavior of the Recorder. The movement of the Recorder on the chart simulates travel over the ground under wind conditions. This movement is governed by the Wind Drift Mechanism, located in the base of the Trainer. The mechanism consists of an assembly of gear trains so arranged that when the various elements of the wind drift problem are led into it, the output is track and ground speed.

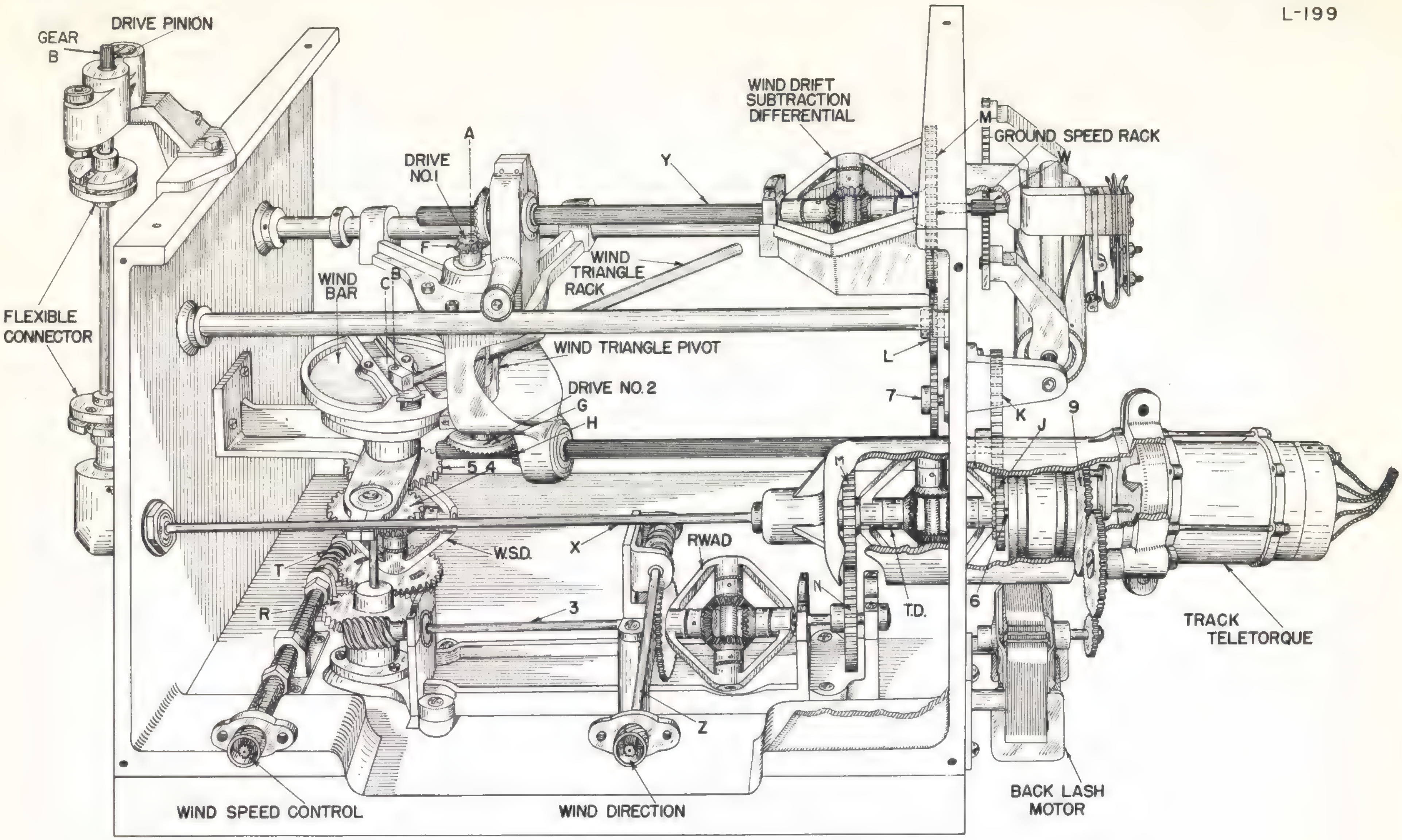
In operation, wind direction and wind velocity is applied to the Trainer heading and airspeed by the instructor, either before or during a problem. This is accomplished by turning the wind velocity and wind direction cranks on the right hand side of the desk to the desired settings. The wind velocity dial at the desk goes from a zero setting to 60 miles per hour wind velocity, the wind direction from 0 degrees through 360 degrees.

Conditions to be represented in terms of the Wind Triangle

The Wind Drift Mechanism may be called a mechanical professor which constantly solves the wind triangle automatically. Into it are put (1) Heading - by Trainer rotation (2) Airspeed - by throttle setting and Trainer attitude (3) Wind direction - manually and (4) Wind velocity - manually. Out of it come track and ground speed.

The three sides of the wind triangle are usually drawn and labeled for graphic solution in the form (1) Heading and Airspeed (2) Wind Direction and Velocity (3) Track and Ground Speed, and are all subject to change, both in direction and length. However, in the wind triangle used in the Wind Drift Mechanism (see Figure 22), one of the sides (AB) is fixed in direction and for mechanical reasons the wind triangle elements are arranged as follows: (1) Airspeed - (AB), (2) Wind Speed - (BC) and (3) Relative Wind Angle - (ABC), the latter being the angle between the heading and the wind direction. From these are produced the Ground Speed - (CA) and the Drift Angle - (CAB).

To illustrate how the wind triangle in the Wind Drift Mechanism meets the necessary conditions:- an aircraft in flight on a North heading at 160 miles per hour airspeed encounters a wind from the East blowing at 60 m.p.h. The relative wind angle is 90° right. The aircraft, under these conditions, will be blown to the left at an angle of 20° to the heading, that is, the drift angle will be 20° left. Consequently, the track will be $360^\circ - 20^\circ$ or 340°. The ground speed will be 171 m.p.h.



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WIND DRIFT MECHANISM

FIG. 22.1

The Mechanical Wind Triangle in the Mechanism

The wind may be thought of as always blowing down the side BC. AB may be thought of as representing the heading of the aircraft relative to the wind. Angle ABC is the angle which the heading of the aircraft makes with the wind, or the relative wind angle. Since the direction of the side AB is fixed, this angle is varied by rotating the wind bar BC (See Figure 22). When the Trainer rotates (change of heading), the wind bar rotates in the same direction as the Trainer. When the wind direction is altered, the bar rotates in the opposite direction to the shifting wind. The two movements are applied simultaneously to the wind bar through a differential "RWAD", Figure 22.1, (the relative wind angle differential). Heading is led into the Wind Drift Mechanism through gears at the bottom of the Trainer main spindle through flexible connections as shown in Figure 22.1, which drive shaft "X" and wheels "M" and "N"; wind direction from the instructor's handcrank through shaft Z. The output of RWAD is applied to the wind bar through shaft 3 and gears R, 4 and 5.

As the wind bar rotates, the rack AC applies the drift by its pivoting movement at A (Figure 22.1) and the ground speed by its sliding motion through A. Figure 22.2 gives a side view of the same parts and in addition, shows how the two distinct drives are taken off the wind triangle rack: Wind triangle pinion drive, No. 1 and Wind triangle pivot drive, No. 2.

MAIN WIND SLIDE

L-200

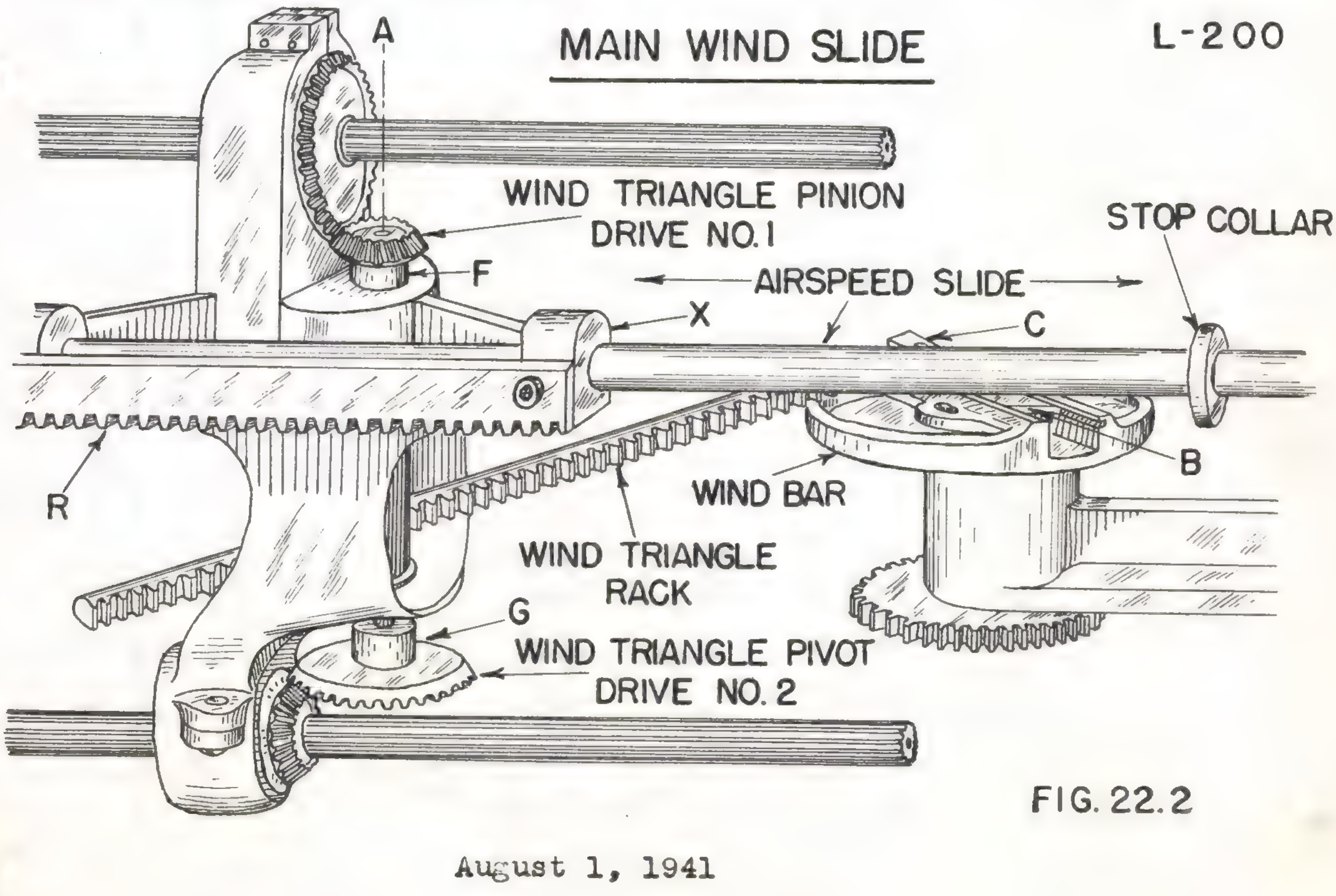


FIG. 22.2

APPLICATION OF THE DRIFT AND GROUND SPEED MOVEMENTS

(a) Pivoting or Drift Movement

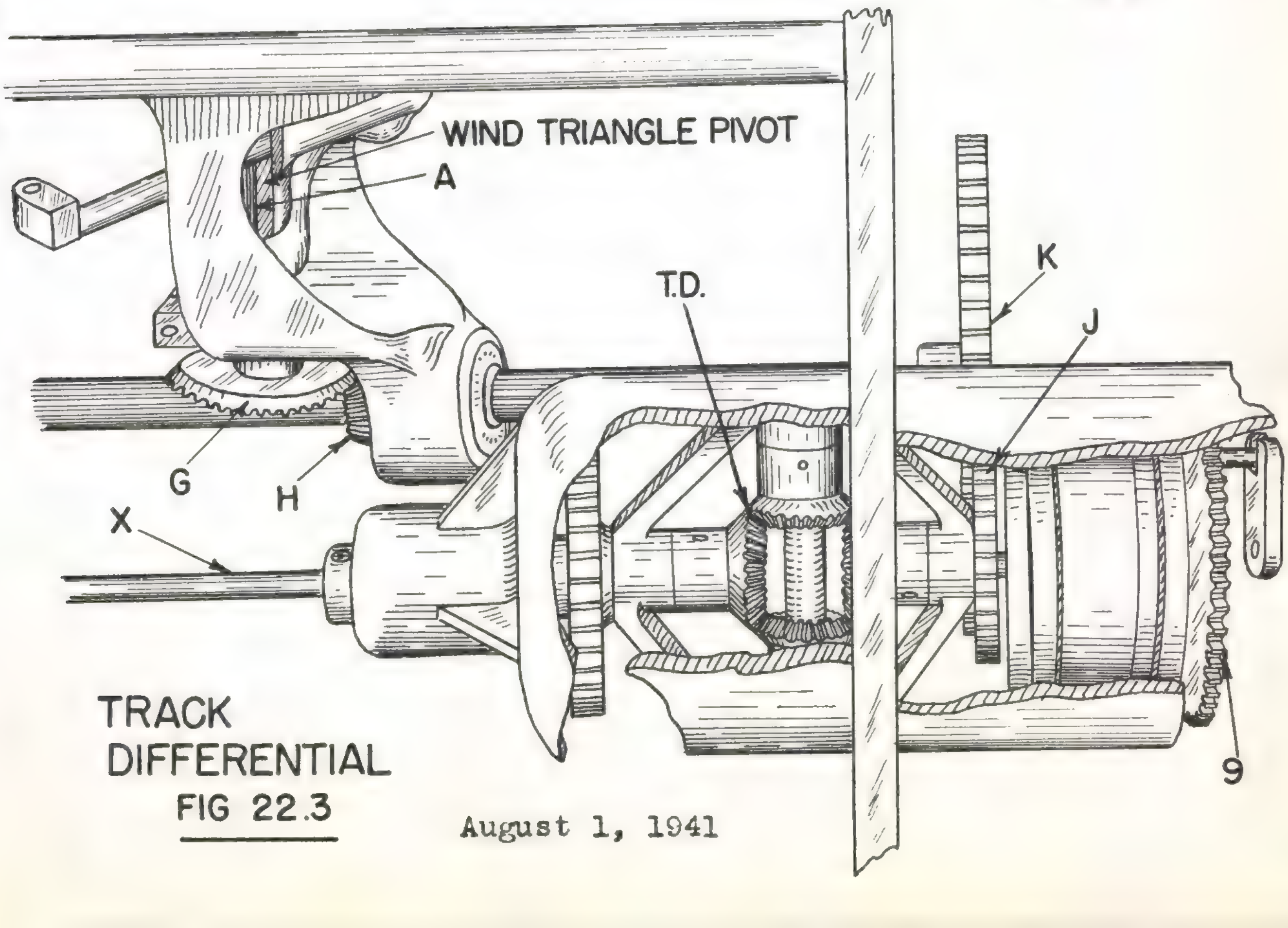
One required output of the mechanism is the "track". Since the pivoting movement at A gives drift, to obtain the track it is necessary to add the heading to the drift algebraically. This is done at the track differential ("T.D." Figure 22.3). The drift angle is taken from the wind triangle pivot at "A" and the heading from the shaft "X". The two movements are led into the differential "T.D." and coordinated. The output is the "track".

The stages by which the track is arrived at are as follows:
Heading Component: Gear attached to Trainer spindle, to pinion on universally mounted shaft through bevel gears, to primary drive "X" of track differential in Wind Drift Mechanism.

Wind Drift Component: Gear wheel "G" bolted to the wind triangle pivot, through gear wheel "H" to wheel "K"; from wheel "K" to the secondary drive of the track differential "J".

The output shaft ("G") of the differential drives the master Teletorque which governs its dependent in the Recorder, thus controlling the direction of travel, or track of the Recorder.
NOTE: In order to remove back lash in the gear trains a constant speed motor is geared in at wheel 9, Figure 22.3.

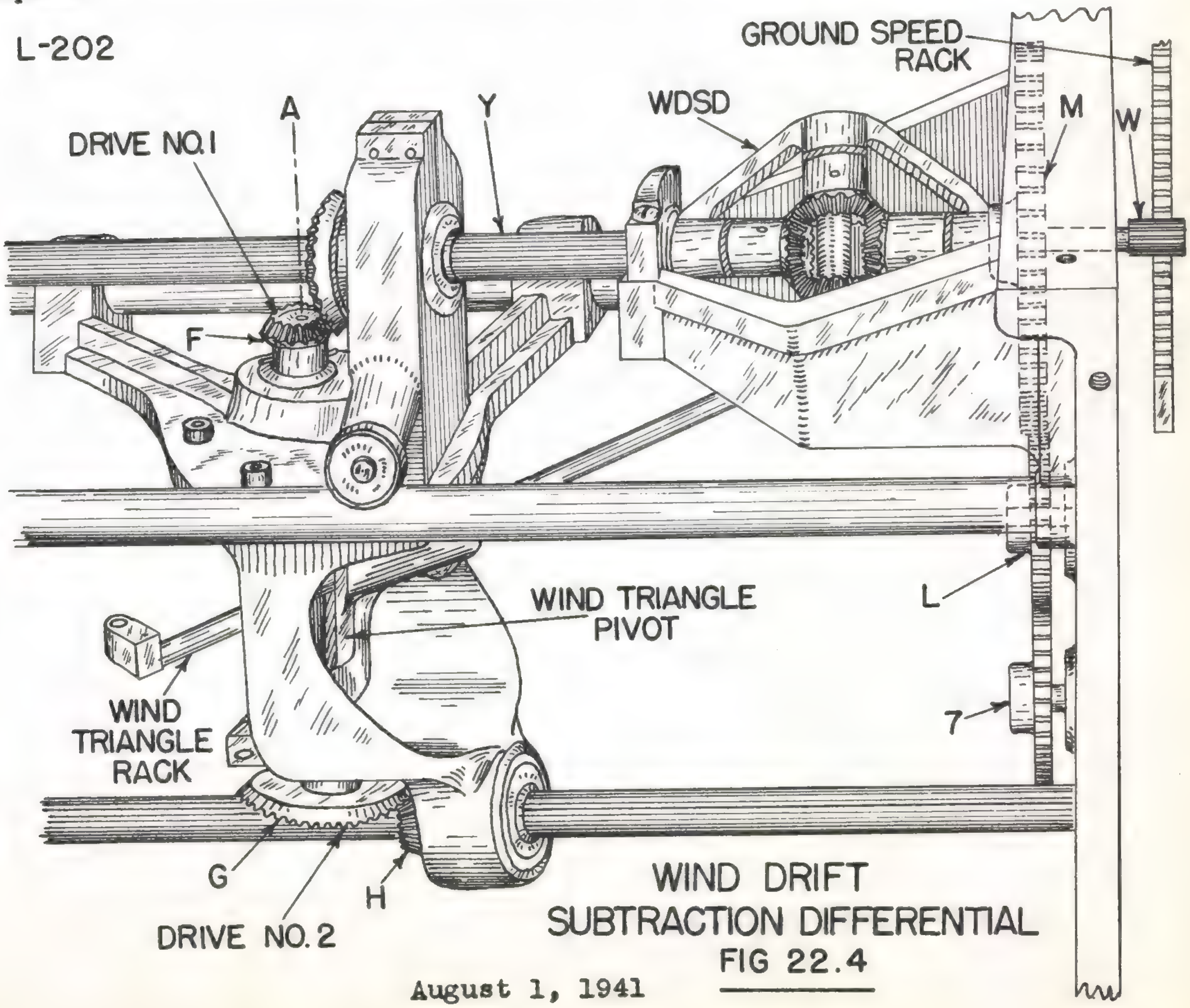
L-201



TRACK DIFFERENTIAL
FIG 22.3

(b) Application of the Sliding or Ground Speed Movement

As was illustrated from the wind triangle, "ground speed" is obtained by the sliding movement of the wind triangle rack through "A". However, it will be observed from Fig. 22.4 that it is not possible to take off from the pinion "F" at "A" the sliding motion alone. When given sliding motion, the rack not only slides but pivots at the same time, giving an additional movement to the pinion "F", which would represent additional wind drift. To obtain the ground speed alone, the drift must be removed. This is done by means of a differential--The Wind Drift Subtraction Differential (WDSD), Figure 22.4. Into one side of the differential is led the combined pivoting and sliding movement of the wind triangle rack through shaft "Y". Into the other side of the differential is led the pivoting motion alone, through "H", "7", "L" & "M". This latter drive works against the drive from the wind triangle rack. Thus, the output of the differential is the sliding plus the pivoting motion, less the pivoting motion which equals the sliding or ground speed movement alone. The output is applied to pinion "W". The ground speed movement is used to control the speed at which the Recorder travels over the chart, or actually the ground speed.



WIND DRIFT SUBTRACTION DIFFERENTIAL
FIG 22.4

Variation of Airspeed and Wind Speed

Air Speed Control

The airspeed component of the triangle is varied by altering the distance between the pivot "A" and the pivot of the wind bar "B" (See Figure 22.2). The wind bar pivot is fixed. The wind triangle pivot housing is mounted on a slide (airspeed slide) and is free to move towards or away from the wind bar pivot. The pinions "G" and "F" are free to slide on their splined shafts.

The position of the wind triangle pivot on the airspeed slide is controlled by a two way "follow up" motor, which acts through pinion "D" and rack "R", the rack being attached to the wind triangle pivot housing. See Figure 22.5.

The direction and length of time this "follow up" motor runs is controlled by a rotary switch "O". One side of the rotary switch (the contact point) is attached to a pulley around which is led a cable. This cable passes over pulleys through the main spindle into the fuselage to the airspeed reversing lever. Changes in airspeed move the cable, which is under tension in one direction because the pulley is spring loaded. The other side of the rotary switch, which consists of 2 plate sections, is attached to the pinion D. Contacting each plate section (one for clockwise, the other for counterclockwise rotation of the motor) is a brush "C", which carries one side of the circuit to the "follow up" motor. (The periphery of each plate is cut away into a cam section to prevent running the motor beyond the limits of the rack.)

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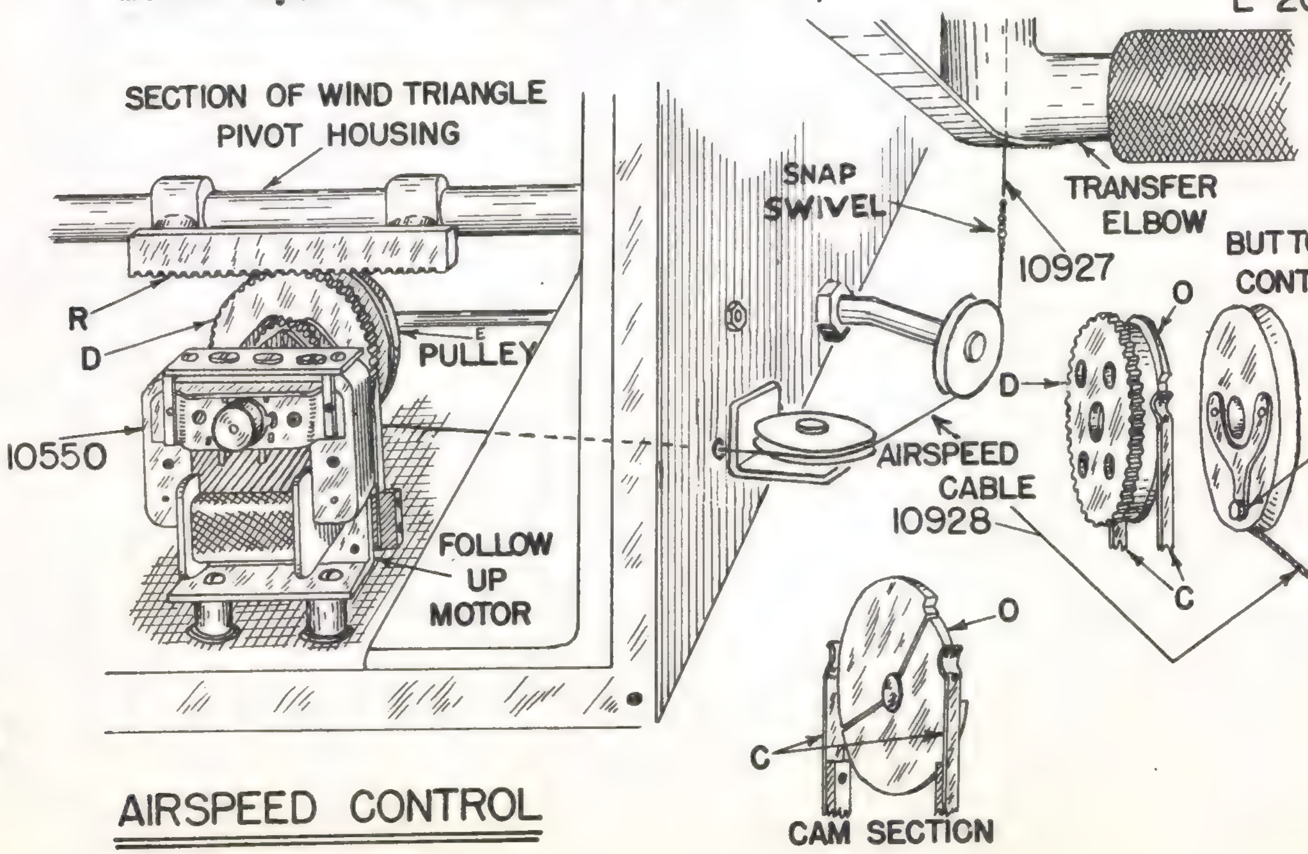
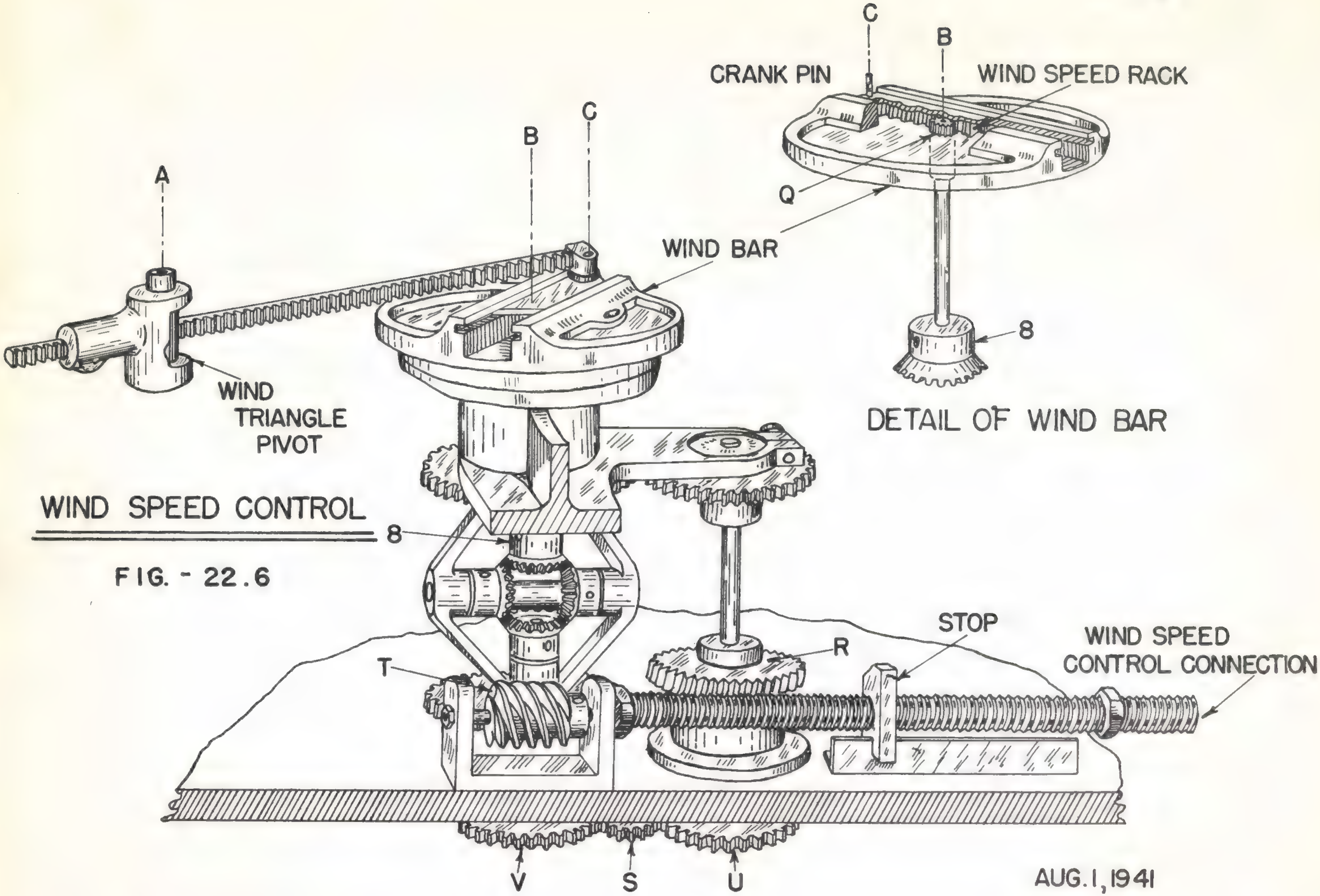


AIRSPEED CONTROL

FIG. 22.5



WIND SPEED CONTROL

FIG. - 22.6

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Principle of Operation: When the pulley rotates (due to change in airspeed), the contact point on the gear "E" makes contact with one of the plates attached to the disc on pinion D. This completes the circuit to the follow up motor which rotates. This turns the pinion "D" which drives the rack and the wind triangle pivot attached to it. The disc with the plates also rotates with the pinion, until a gap between the plates reaches the contact point on the gear wheel "E", stopping the follow up motor.

(b) Wind Speed Control

Wind speed is varied by altering the distance between "B" and "C". The slotted wind bar accommodates a rack which slides in the bar. The rack is driven by a pinion "Q" in the center of the wind bar (see Figure 22.6). As the pinion revolves, the crank pin at "C" moves towards or away from the center of the wind bar, decreasing or increasing the wind speed.

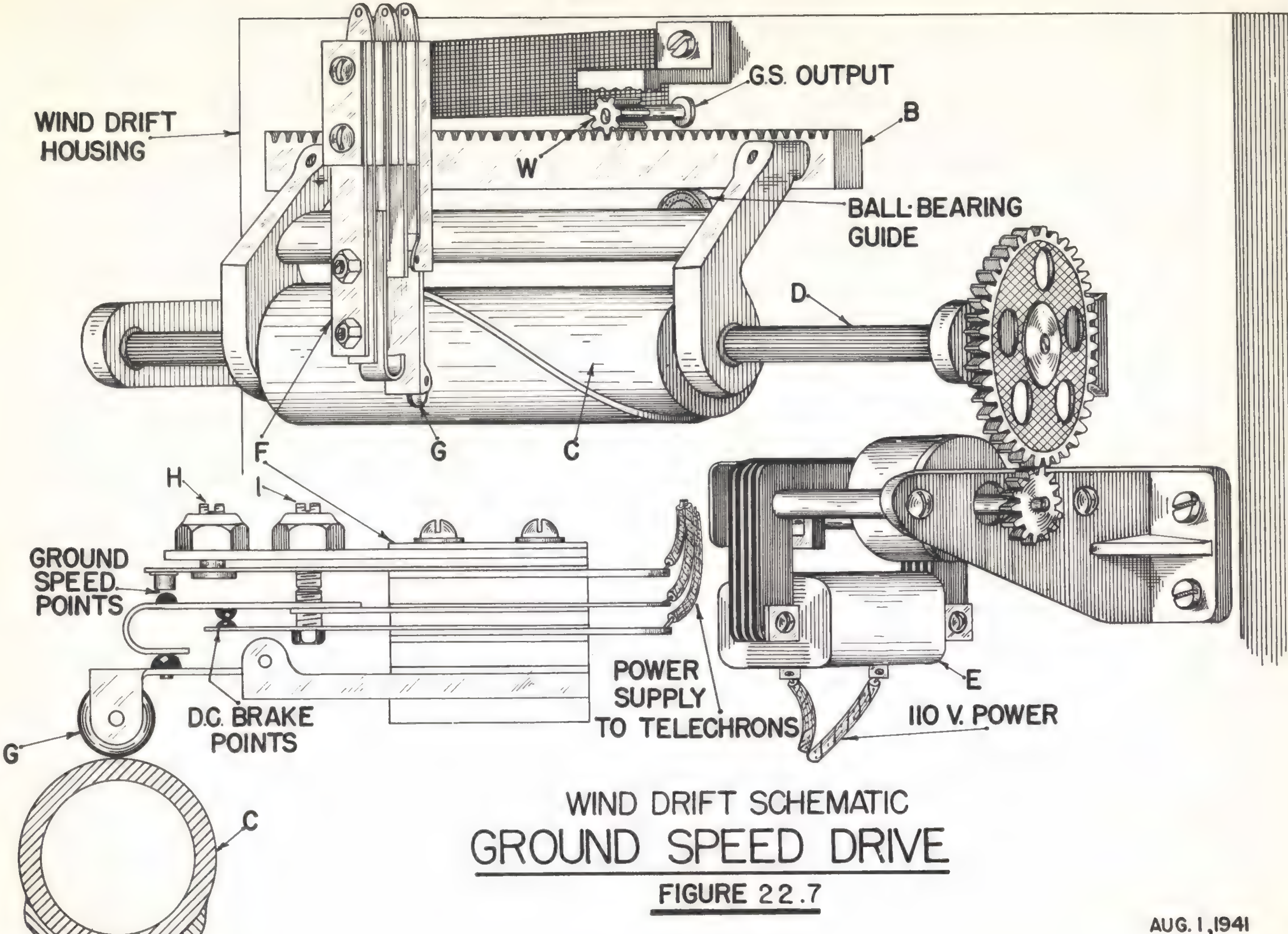
However, were the drive to the rack a direct one, the setting of the crank pin would be disturbed whenever the wind bar revolved. (The pinion at B remains stationary and the rack rotates about it, causing the pinion to drive the rack.) To allow for the fact that the wind bar revolves with the Trainer heading, a differential is provided, which turns the pinion at B in the same direction as that in which the wind bar is revolving. From Figure 22.6 it can be seen that when the wind bar rotates, its movement will be transmitted through wheels "R", "U" and "V", through the primary drive of the differential to the pinion at B, the drive being reversed at wheel "S". Thus the rotation of the Trainer is prevented from having any effect on the setting of the crank pin. The wind speed is set by hand by worm gear "T" through the secondary drive of the differential to the pinion at B. The wind may be varied from zero (when the crankpin "Q" is directly over the center B) to 1/2 the normal cruising speed of the Trainer, when the rack is fully extended and the pin is at the furthest possible distance from B.

Application of the Wind Drift Mechanism output

to the Recorder

The Wind Drift Mechanism output consists of two movements--one represents change of track, the other change of ground speed. The movements are transmitted to the Recorder by means of a Teletorque unit and an intermittent motor control for the telechrons. The Recorder is similar to the ones in use on C, D and E Trainers. The drive wheels are given motion by means of two telechron motors, while both drive and inking wheels are rotated by means of a teletorque in the center of the Recorder.

With zero wind, the Recorder Teletorque turns the wheels to the same direction as the Trainer is headed (provided the Recorder has been synchronized properly with the Trainer - See Section 7, Chapter 1, Page 1, describing this procedure).



WIND DRIFT SCHEMATIC

GROUND SPEED DRIVE

FIGURE 22.7

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This is accomplished through the master Teletorque on the outside of the Wind Drift Mechanism case. Rotation of the Trainer rotates the master teletorque armature which rotates the Recorder Teletorque armature. When wind is cranked in, the drift angle is taken from the main wind slide pivot at 'A' (Figure 22.2). The two movements, heading and drift angle, are then led to a differential and there coordinated. The output--track--is led to the master Teletorque.

The stages by which the track is arrived at are as follows:
Heading Component: Gears and linkage at spindle in base of Trainer, to primary drive of heading - track differential ("D") in the Wind Drift Mechanism.
Wind Drift Component: Gear wheel 'G' bolted to the main wind slide pivot, through pinion H to gear K, to secondary drive of the heading--track differential.

The output shaft of the differential drives the master Teletorque, which in turn controls the Recorder Teletorque.

Ground Speed Drive

To obtain variable Recorder speed to simulate varying ground speed, the circuit which supplies the power (current) to the two Recorder Telechrons is made intermittent. The length of time the circuit remains broken or completed determines the ultimate distance that the Recorder will travel in any given time.

The "making" and "breaking" of the current is the function of the ground speed drive. See Figure 22.7.

Constant speed motor "E" through gears rotates splined shaft D, which keeps cam roller 'C' turning constantly. The brackets for the cam roller are attached to rack B, motion to which is given by pinion 'W'. Pinion 'W' is governed by the ground speed component of the triangle (See (b)--Application of sliding or ground speed movement). The position of the rack determines the position of the cam roller on the splined shaft. The small roller 'G' on the fixed "make and break" (or switch) points block 'F' then allows the points to open and close as the small roller 'G' rides on the cam roller 'C'. The length of time the points are closed during one revolution depends on the position of the cam roller on the splined shaft, which is dependent on the ground speed output of the Wind Drift Mechanism.

D.C. Brake Assembly

Telechrons operated on an intermittent circuit have a period of over run or coast when the circuit is broken, which is sufficient to destroy the calibration of Recorder travel. It is therefore necessary to provide a brake which locks the telechron armature at the instant the 110 volt circuit is broken. This is the function of the D.C. brake assembly, consisting of a 15 volt transformer, a rectifier and a condenser. Its output, 12-18 volts D.C., is applied to the telechrons when the 110 volt circuit is broken. See Figure 22.7. When roller G is on the high part of cam roller C, the ground speed points are closed, supplying the Recorder telechrons with 110 volts A.C. operating

current. When the roller G is on the low part of cam roller C as illustrated, the D.C. brake points are closed, supplying the Recorder telechrons with direct current, which instantly prevents the armature from rotating further. Adjustment of these points is covered in Chapter 7C.

Summary

The Four Racks

The Wind Drift Mechanism utilizes four racks:

1. The Wind Triangle Rack

   Through the wind triangle rack the wind triangle pivot receives the wind drift movement, and the wind triangle pinion receives the ground speed movement.

2. The Ground Speed Rack

   The rack is driven by a pinion which moves in proportion to the value of the changing ground speed of the simulated aircraft. The rack determines the position of the cam roller which provides for an intermittent control of the Recorder Telechron drive motors.

3. The Wind Speed Rack

   The wind speed rack is the agent by which the length of the wind speed vector is varied. Set in the wind bar, it is driven by a pinion, special provision being made for the wind bar to rotate without disturbing the setting of the rack.

4. Airspeed Rack

   "R" in Figure 22.5 is driven by the airspeed "follow up" motor and determines the value of the airspeed side of the triangle.

The Four Differentials

In all, the Wind Drift Mechanism utilizes four differentials. The following is a summary of their uses.

1. Track Differential. The drives: (1) Heading (from the heading gear box) (2) Wind Drift Triangle pivot. The output: Track (relayed to master teletorque).

2. The Wind Drift Subtraction Differential. The drives: 1. Ground speed plus drift (sliding and pivoting movement of main wind slide rack); 2. Wind drift (wind triangle pivot). Output: Ground speed (relayed to master teletorque).

3. Wind Speed Differential. The drives: 1. Wind bar rotation; 2. Wind speed control. Output: Wind speed (relayed through wind speed rack to wind speed crank pin).

4. Relative Wind Angle Differential. The drives: 1. Trainer heading (from heading gear box); 2. Wind direction control. Output: Relative position of heading to wind direction.

Maintenance & Adjustment

The mechanical parts of the Wind Drift Mechanism require no servicing. Once the unit is installed, the mechanism should function satisfactorily until it wears out. All bearings are either oilite or provided with lubricant sufficient for the life of the unit. In the event of failure or fracture of any particular piece in the internal mechanism, the entire Wind Drift Mechanism should be returned to the manufacturer for replacement.

The electrical units, such as the rotary switch for airspeed control may, however, be serviced by any good electrician who has had experience with this type of switch. Should the teletorques fail to function, they can be replaced by new units and correctly synchronized.

The constant speed ground speed drive motor is a telechron and should also not require servicing, since the gear box is provided with enough lubricant to last a lifetime.

Adjustment

In the original installation of the Trainer and during subsequent weekly or periodic checks, the length of Recorder travel at cruising should be checked against the cruising airspeed indication and adjustment for correct travel should be made if required.

With the wind velocity set to zero, the Recorder should travel .845" per minute. Adjustment is made by varying the distance AB in Figure 22 or Figure 22.5 by lengthening or shortening the electric throttle cable at the snap swivel outside the Wind Drift Unit between it and the transfer elbow. A more definite check may be obtained by measuring the distance between the end of the airspeed slide bracket at X and the stop collar, see Figure 22.2. At indicated cruising airspeed, this distance should be adjusted to 15/16" by the means described above.

As a matter of interest 10 m.p.h. of Recorder movement is represented by:

5/32" movement of the airspeed slide
7/64" movement of the electric throttle cable
3/32" side movement of the ground speed cam.

Method in Detail

#1 Method:

1. Check the airspeed system for correct adjustment and for airspeed regulator spring tension. (See Section 2, Chapter 6, for details.) Adjustment to the Wind Drift Mechanism cannot be made unless this is done first.
2. Check wind velocity for zero setting (as a double check see that point C is over point B, Figures 22 or 22.2).
3. Set airspeed indicator to 160 mph. (Trainer locked level "floating")
4. Run Recorder from a definite starting point, 5 (or 10) minutes by a stop watch.

5. Measure the length of the line and divide by the number of minutes for the run.

6. If the run per minute is longer than .845" loosen the set screw at the snap swivel between the transfer elbow and the Wind Drift Mechanism and allow the cable to move slightly into the wind drift box. If the distance per minute is shorter than .845 loosen the set screw and pull outward slightly on the cable. (1/8" movement of the cable equals 10 m.p.h. of Recorder travel.)

#2 Method:

1, 2, 3. Same as in #1 method.

4. Check distance between end of airspeed slide and the stop collar face. This should measure 15/16". If the distance is less, loosen the throttle cable and shorten (pull out of the W.D. box) and vice versa.

5. As a double check make the above described 5 or 10 minute run.

NOTE: Charts used with C-3 or C-5 Trainers must be drawn to scale if the results are to have any meaning. Since .845" per minute at 160 m.p.h. represents 2.666 m.p.m., 1 inch equals 3.155, or roughly 3.2 miles.

Adjustment of Contact Points

The points are adjusted at the factory so that at the moment one contact is broken the other contact is made--no appreciable interval existing between supplying the telechrons with either the 110 Volt alternating current or the 12 Volt D.C. Too wide a gap brings about excessive over run or coast. This upsets calibration of the units and destroys the accuracy of the tracking speed. Too close a gap, or simultaneous contact between the two sets of points overloads the line and may blow fuses. The desired adjustment can be made by turning the constant speed motor of the unit over slowly by hand (power off) watching the points as they make and break and screwing in or out on the adjustment H and I. Adjustment H positions the ground speed point while adjustment I positions the D.C. break point.

Procedure for Adjusting Wind Velocity Control

Turn tail of fuselage toward the desk. Then by sighting down past the side of the fuselage square the fuselage with the base. An inspection window is located on top of the Wind Drift Case in the base of the Trainer. Have helper turn "Wind Velocity" crank at desk until small pivot "A", Figure 22.8, visible through the window, is at outer edge of the wind bar "B", Figure 22.8. A positive stop is located in the unit and set at the factory. This should not be forced.

Disconnect the flexible cable from the wind velocity crank at the desk. Set dial at desk to "60". Reattach flexible cable and crank the dial to zero. The pivot "A" should now be in the center of the wind bar "B".

To synchronize the Recorder (Flight Log) with the Wind Drift Unit, switch off the vacuum turbine in the base and turn on the line switch in base junction box. (See Figure 2.1).

Turn on the ignition switch on the right side of the instrument panel and then plug in the Recorder.

Head the Trainer exactly North (tail of fuselage over base junction box and fuselage square with base); rotate the movable dial that has a compass rose graduated on it (0 to 360) until "0" of this scale is opposite the fixed reference pointer ("A", Figure 4).

By means of the three large gears in the Recorder, turn the inking wheel until the movable pointer "B" is over "0" in the movable dial "C" and in line with fixed reference pointer "A".

Let go of the large gears. If the pointer moves away from the "0" it is necessary to correct this in the base of the Trainer.

Check that the Wind Velocity dial at the desk is set at zero.

In the base of the Trainer, spring out bracket "C" (Figure 5.1) enough so that the gears "A" and "B" (Figure 5.1) will clear each other. While holding the bracket "C" out, rotate the small gear "B" until pointer is over the "0" and allow gears to mesh. This operation should not need to be repeated unless at some future time the gears in the base or in the Flight Log have been disassembled. Next time the Recorder is plugged in on the desk, it will only be necessary to rotate the large gears by hand until the pointer agrees with the Trainer heading.

Next, crank the Wind Velocity dial at the desk to maximum wind (60 M.P.H.). Check that tail of fuselage is over base junction box, and by sighting down past the side of the fuselage square the fuselage up with the Trainer base. Looking through the inspection window on top of the wind drift case in the base, have helper turn wind direction crank at desk until the pivot "A" is away from the center of the Trainer and exactly parallel to rack "C" in Figure 22.8, "Showing Maximum Head Wind".

This is a maximum head wind. The flexible cable on the wind direction coupling at the desk should now be removed, the wind direction dial rotated to "zero", and the flexible cable reattached.

(Note: Since the above setting has been made at a maximum head wind, it can be noted that the same conditions apply to any Trainer heading with a "wind" from the same direction.)

(Note: If the Trainer room is such that the desk is not located in the South end of the room facing North, see Chapter 1, Section 7.)

Turn on Trainer ignition switch and set the throttle at cruising, making sure both climb and dive valves are closed and Trainer is floating in lock straps, (see Chapter 6, Section 2, "Locked Level Cruising"). The airspeed reading must be exactly on cruising for this check, as the whole adjustment of the Wind Drift Unit is based on this first step.

Connect the cable to Recorder Flight Log and let it run a minute or so, to allow telechron motors to warm up. Handle the Recorder carefully.

Place the Recorder on a piece of white paper on the desk and with a stop watch, note travel of Recorder in one minute, making sure that the airspeed is at cruising and both the Wind Velocity and the Wind Direction dials at desk are at zero. Use 2 R.P.M. telechron motors for this check. Recorder should have traveled 27/32" (.845) in one minute. If travel of Recorder is short of 27/32", shorten bronze cable up in fuselage by loosening nut "C" on pivot clamp ("A", Figure 22.8) which is located on top of airspeed lever arm, and pull the bronze cable through a bit. Tighten nut and set the throttle at cruising and check Recorder again for one minute.

If the travel of the Recorder is over 27/32 (.845), loosen nut ("C", Figure 22.8) on airspeed lever and loosen cable up a bit. Check the travel of the Recorder several times. This is the main adjustment and must be correct so that the following changes in the Wind Velocity and Wind Direction will be correct.

Decrease the airspeed reading to 120 M.P.H. by closing the throttle very slow and allowing the hand on airspeed indicator in Trainer to fall back to 120 M.P.H. Make sure that the Trainer is floating in its straps and that the hand on airspeed indicator is right on 120 M.P.H.

Note the travel of the Recorder for one minute, using stop watch. The Recorder should have traveled 41/64" (.640). If this reading is above 41/64" (.640) in one minute, loosen nut ("D", Figure 22.8) on airspeed lever arm and move clamp up.

Open and close throttle smartly and reduce airspeed to 120 M.P.H. and check travel of Recorder again. If the travel of the Recorder is under 41/64" (.640) in one minute, loosen nut ("D", Figure 22.8) on airspeed lever arm and move clamp "A" down a small amount, making sure that nut is tightened up after each adjustment. When this adjustment is correct, check the Recorder travel at cruising again for a double check.

The next step is to check Wind Velocity by adding 20 miles head wind. Do this by turning crank on Wind Velocity at the desk and setting dial to 20. (The Wind Direction is still at zero.)

Set the Trainer at cruising and check travel of Recorder for one minute, which should travel 47/64" (.734).

Next, check the Wind Direction by cranking in a Wind Direction of 180 degrees at the desk. Leave Wind Velocity dial at 20. The Recorder should now travel 61/64" (.953) in one minute (Trainer still at locked level and cruising).

These two last checks should be correct if the first adjustments were made correctly and serve merely as a double check on previous adjustments.

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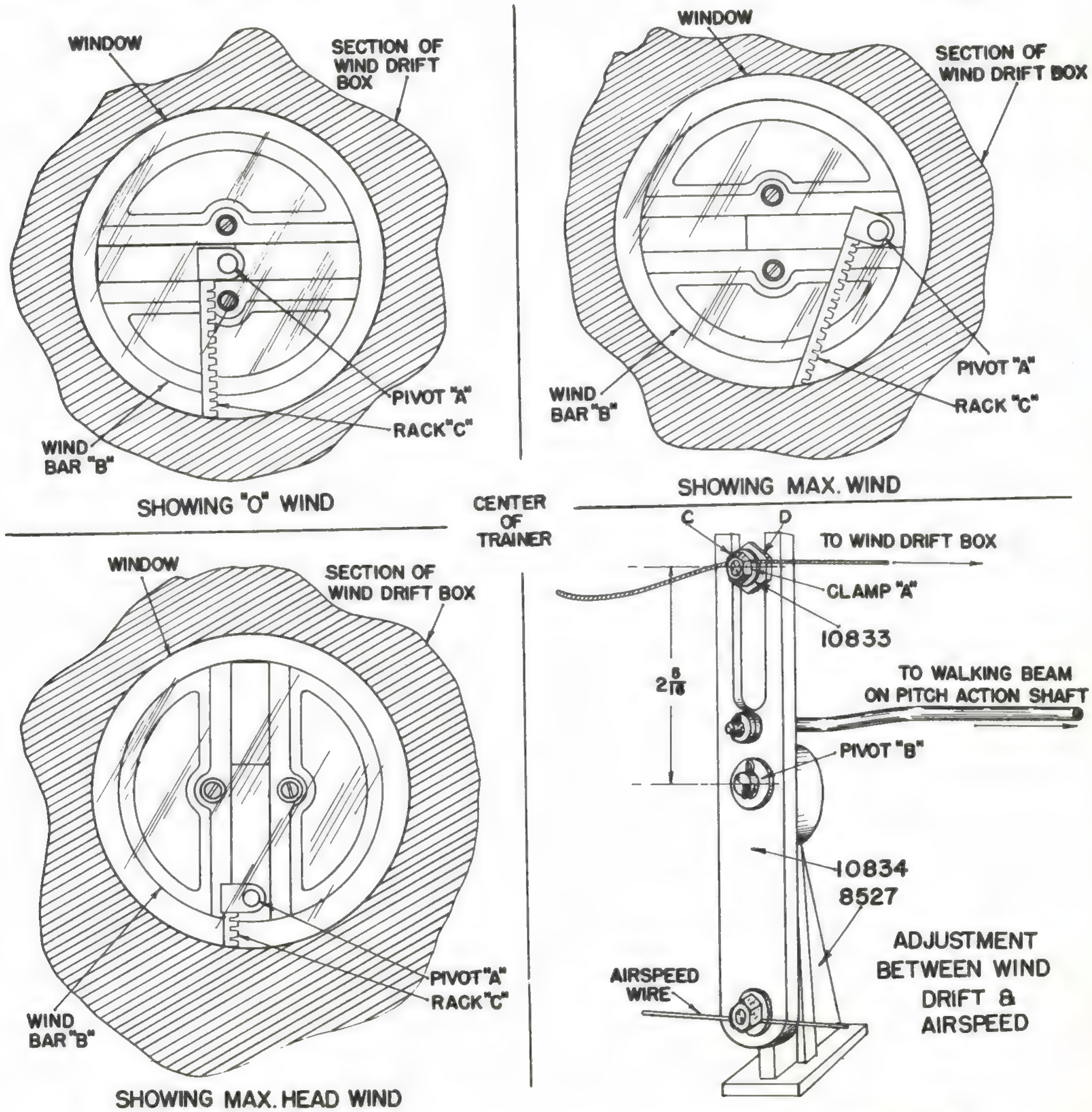


FIG 22.8

AUG. 1, 1941 WIND BAR & AIRSPEED ADJUSTMENT

SECTION XV

TRAINER LOCKING (LEVELING) DEVICES

Two separate devices are provided with which to lock the Trainer in a level position when it is not in use or when adjustments are being made.

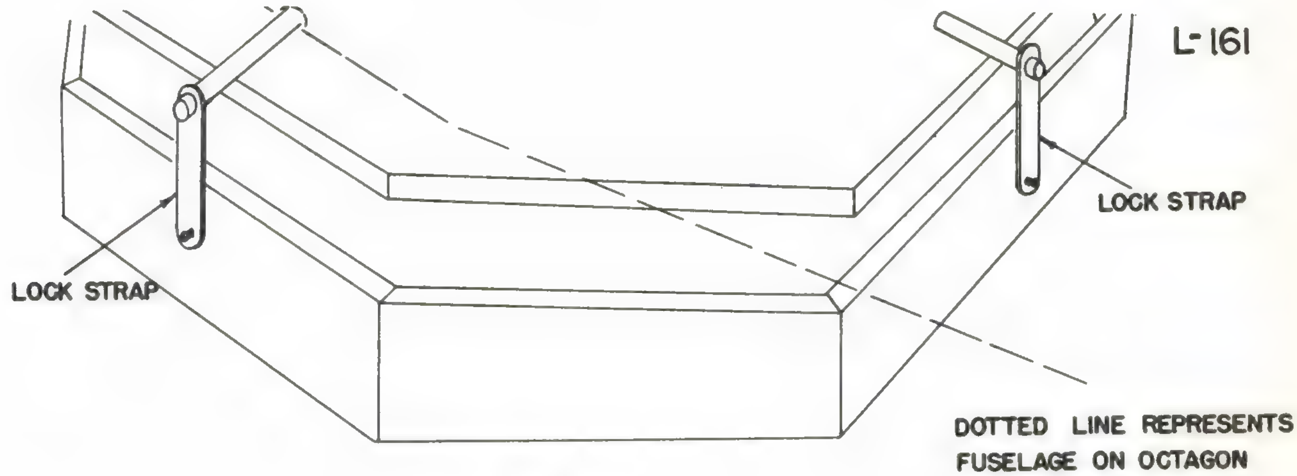
One system consists of two simple straps as illustrated in Figure 23 . The other system consists of a hydraulic jack operating a lever arm which in turn pulls four cables attached to four points on the octagon to pull the fuselage to a level position and hold it there (See Figure 23). The first system (lock straps) is used primarily for making adjustments within the Trainer fuselage where the "locked level" position is used as described in the sections dealing with Trainer adjustments. When the lock straps are thus being used, the other system must be released.

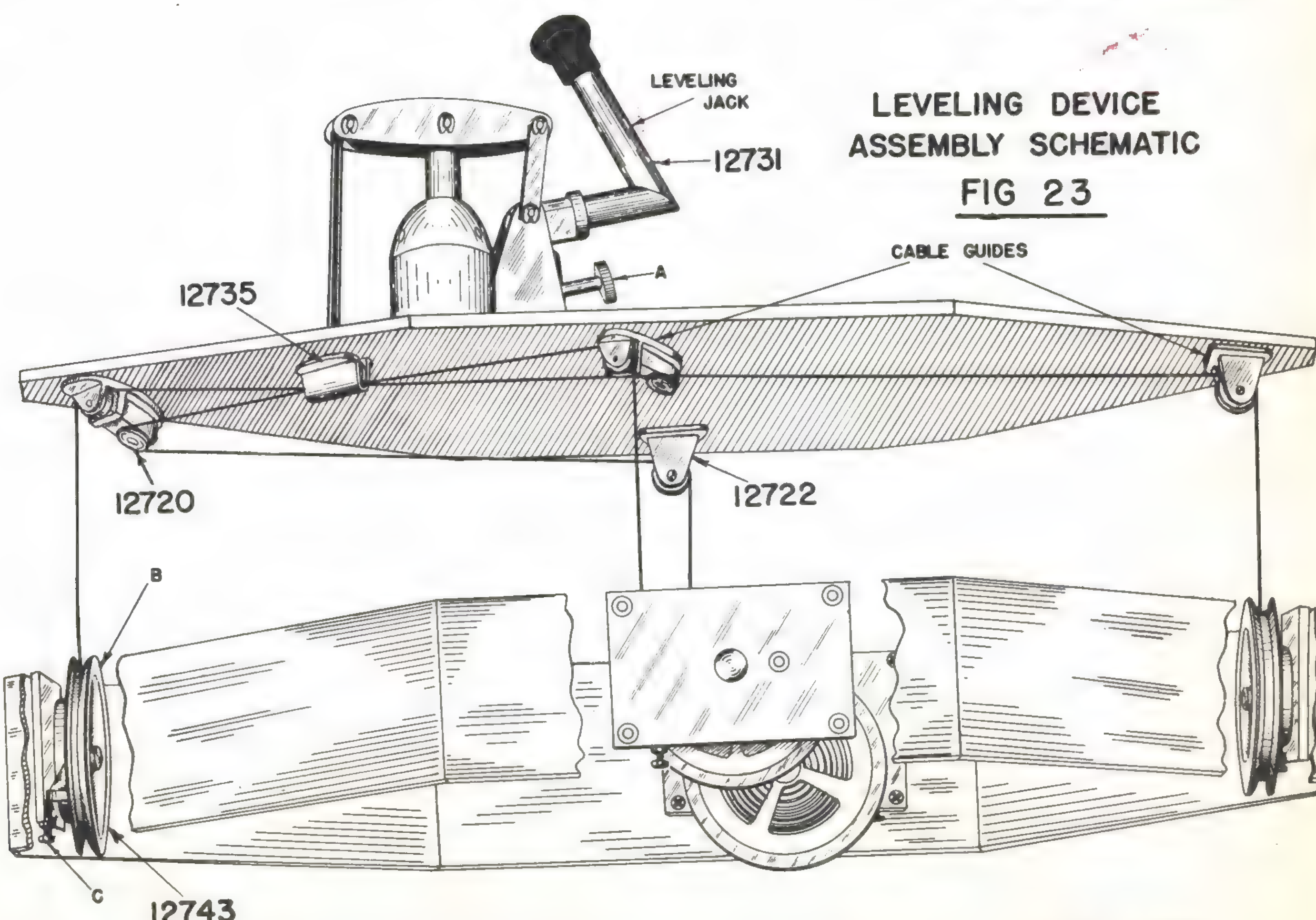
When the hydraulic system is being used, the lock straps are swung aside against their stops out of the way. The hydraulic device is designed so that it can be operated either by the student sitting in the Trainer cockpit or by the instructor standing outside on the floor. To release the fuselage ready for flight, partially open the valve (A in Figure 23). To relevel the Trainer at the end of the flight see that the above valve is closed and pump the handle. The Trainer main switch (ignition switch) may be turned on or off either before or after locking or unlocking the Trainer with the hydraulic leveler. However, if the Trainer is still running while being leveled, it should be flown to a nearly level position instead of forcing the hydraulic jack and the cables to overcome the pull of the main bellows as explained in Section 2, Chapter 2, under "Operating Instructions".

Referring to Figure 23 , it will be seen that the lower end of each of the four cables goes to a drum on the octagon. When the hydraulic jack is released all four cables tend to slacken and sufficient slack must be provided to permit the Trainer to bank or nose up and down through the full range of its travel. In order that the cables do not kink or become entangled during this process, the drum "B" in Figure 23 was provided. When the Trainer is locked level with the jack pumped up to its top position, the cables are taut and the pulleys are held against the stop "C" in Figure 23 . Note that a strong coil spring is attached to this pulley. When the jack is released, the cables slacken. This coil spring turns the drum and winds up, or reels in, the slack in the cable. The spring is sufficiently strong to maintain proper tension on the cable at all times during operation and yet permits the fuselage to be fully banked or fully nosed up or down, the drums at all times maintaining the tautness in the cable.

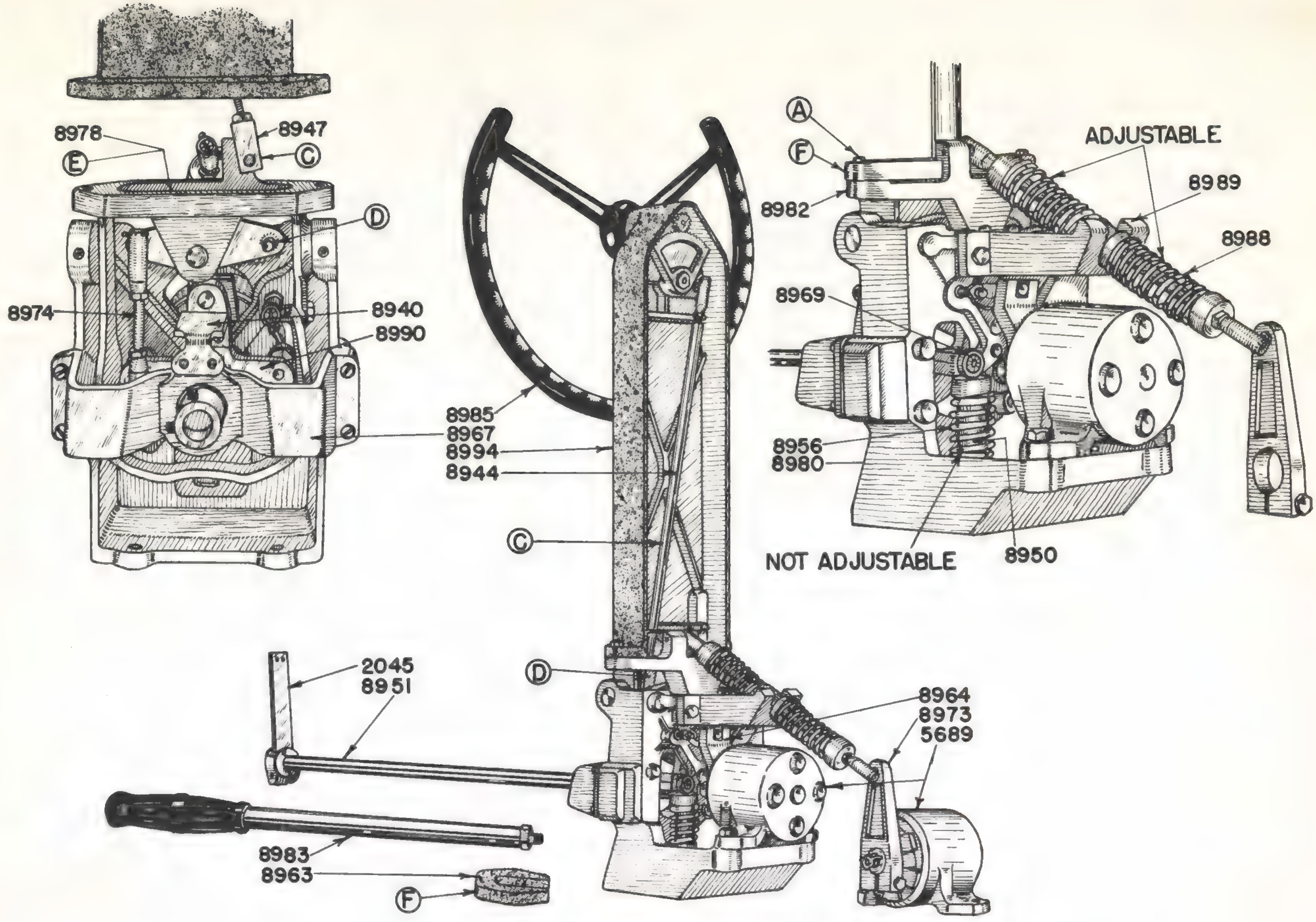
When the hydraulic jack is operated to again level the Trainer fuselage, the cables are pulled until the drums, against the tension of the coiled spring, have been turned against the stop "C" in Figure 23. When the drums have reached this point and can turn no further, continued pumping on the jack and further pull on the cables brings the Trainer to its level position.

Deflectors are used at each drum to prevent the Trainer skirt from fouling the cables and drums.





LEVELING DEVICE
ASSEMBLY SCHEMATIC
FIG 23



INTERCHANGEABLE
STICK & WHEEL CONTROL
FIG. 24

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SECTION XVI

INTERCHANGEABLE STICK-WHEEL CONTROL

This unit affords a ready method of changing from stick control to wheel, or vise versa. To change from wheel to stick remove the two cap screws (A) at the base of the wheel column (Figure 24). Slide the column back slightly on the base to disengage the long control rod (C) from the stud (D) and remove the wheel assembly. The metal control stick may now be screwed into socket (E) by hand. To install cover plate (F) use the same cap screws used to secure wheel column.

To change from stick to wheel simply reverse the procedure. However, insure that the long control rod and stud are engaged before tightening cap screws.

Aileron and elevator control pressure is accomplished by means of spring action set at the factory and are not adjustable in the case of the aileron action. The aileron control linkage is also fixed except for the "ball joints", where excess play is removed from the linkage. With the wheel installed, centering of the wheel is accomplished by lengthening or shortening the long diagonal control rod located in the wheel column.

Control loading is accomplished by slipstream simulators which are adjustable so that the control loading may be varied to simulate different types of aircraft. However, this loading must be enough to prevent the spring action from exactly centering the controls when displaced from their neutral position. This is accomplished by changing the position of the "square" nut on the end of the simulator shaft, as described in Chapter 2, Section 13, Page 1.

With the aileron slipstream simulator in place, the square adjusting nut is inaccessible, making it necessary to remove the simulator to adjust it. This is accomplished by removing the two cap screws which hold it in place. With the simulator removed, the action of the loading can be changed in the usual manner by adjusting the "square" nut on the end of the shaft.

The elevator slipstream simulator is accessible and is adjusted in the usual manner.

AILERON CONTROL LOADING SPRINGS

Several operators of Link Trainers have requested that the aileron loading springs be of a lighter type so that the aileron control will have a lighter touch when the stick is used instead of the wheel.

Such a light spring would not be satisfactory for wheel operation and, consequently, the standard installation is being continued as before. However, an additional pair of lighter springs are provided in the tool kit of currently produced Trainers. Where it is desirable for the operator to simulate airplanes with a light feel on the aileron control, these spare springs should be installed. It should be remembered that these springs are not heavy enough for normal feel in a wheel control, so if the stick is removed and the wheel control reinstalled, the heavier springs also should be reinstalled.

Replacement of Springs

With the wheel control replaced by the stick, as described in Chapter 2, Section 16, Page 1 of the Handbook, proceed as follows:

Move the stick to the extreme right and brace or otherwise prevent it from moving back toward the center. This will remove the spring pressure applied to the left spring roller stud #8969, Figure 24

Unscrew the spring roller stud, using a 1/2" open end wrench, and then lift the spring and cap assembly off the guide stud underneath the spring.

Place the stick in the full left position and brace or hold it from returning toward center while the right-hand spring is similarly removed.

Slide the new spring and old spring cap assembly down over the guide studs. Reinstall spring rollers, reversing the disassembly procedure.

<u>NOTE</u>: It may be necessary to compress each spring slightly in order to start the roller stud in the threads. This can be accomplished by pushing down on top of the spring cap by hand.

In most cases the valve in the simulator should be in its fully open position to lessen further the load on the stick.

CHAPTER III

INSTRUMENTS USED IN TRAINER

SECTION I

REMOTE INDICATING AIRSPEED, VERTICAL SPEED, ALTIMETER

These instruments are part of the telegon system of remote indication. The indicators in the cockpit and on the instructor's desk are "repeaters" actuated by "transmitters" located in the rear of the Trainer fuselage.

Each transmitter contains a mechanism similar in principle and design to ordinary aircraft instruments, but instead of having a dial and pointer, this mechanism is coupled to the armature of a telegon motor. As the diaphragm in a transmitter is displaced, the armature of this motor is rotated. This transmitting motor is connected by wires to its two indicators - one in the Trainer, and the other on the desk. Thus any motion of each transmitting motor is instantly duplicated by its two indicators.

Each instrument (altimeter, for example) is composed of one transmitter and two indicators. A detailed description of the electrical system will be found in Chapter 4, Section 5.

SECTION II

FUEL GAUGE

The fuel gauge (Figure 24.1) is a clockwork with a single pointer and a dial graduated in gallons. After being wound up to its full capacity of 50 gallons, it requires approximately one hour to run down.

When the pointer has run down to the zero mark, a switch is automatically opened. This switch is wired in series with the Trainer main switch (ignition swtich) so that when the gauge reads empty and this switch is opened, the Trainer is automatically turned off. A toggle switch is provided, located just above the ignition switch, which is wired so as to bridge the switch in the fuel gauge. When this switch is closed, the switch in the fuel gauge has no effect on the operation of the Trainer.

A special key is provided with which the fuel gauge is wound up like a clock. This key is ordinarily retained by the instructor. The mechanism consists of a main spring, a short train of gears an escapement similiar to that in a clock, plus the switch. The unit can be wound to any value desired by the instructor according to the particular problem about to be run.

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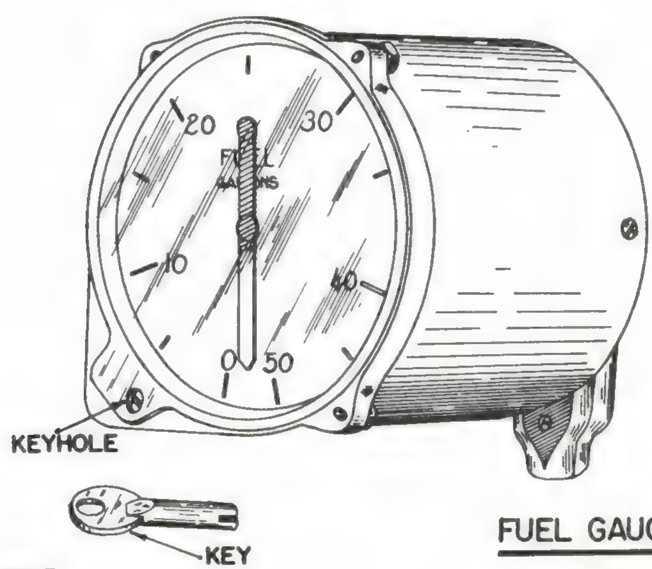

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FUEL GAUGE

FIG 24.1

SECTION III

TACHOMETER

This instrument operates on vacuum supplied by the Tachometer regulating bellows. It is so designed as to require a definite amount of vacuum to move the pointer certain distances around the dial regardless of the numerals appearing on the dials.

The linkages and regulator are engineered to supply just that amount at given throttle settings and attitude of the Trainer.

The proper positions for the pointer are shown in Figure 43. If it is desired to simulate a different cruising speed than appears under the pointer when adjusted according to the chart, it will be necessary to replace the dial.

TURN AND BANK INDICATOR

This is a regular aircraft instrument except that the inclinometer (ball bank indicator) is mounted on a pivot and linked to the gimbal ring of the gyro element. This was necessary due to lack of centrifugal force in the Trainer during a turn.

Some operators prefer a one needle width deflection during a standard rate (180 degrees per minute) turn, and others favor two needle widths. The Turn Indicator in the Trainer may be whichever calibration is specified by the purchaser. If a change is desired from one calibration to the other, it is necessary to change the centering spring. This can be done by any competent instrument repairman.

WARNING: Do not attempt to obtain two needle width indications on a one needle width instrument by increasing the vacuum. This will ruin the instrument.

The manufacturer's instructions for care and servicing should be consulted and followed.

FILTER, MODEL K-1

This unit is designed to remove foreign matter from the air bleeding into the case of the instrument. It should not be allowed to load up with excessive dust and dirt, as this will interfere with the flow of air and slow down the gyro speed, thereby upsetting calibration of the instrument. The filter should be inspected weekly and a new filter installed when needed. Remove the filter assembly from the back or bottom of the instrument, and with the aid of a small screw driver or jack knife, unfasten the snap rings (A) and (B), Figure 25 . The filter unit may then be lifted out of the case (C) and examined to determine whether to replace or to use it again. Under average conditions, the filter unit should

last approximately 100 hours.

In the event that additional filters are not available, a temporary unit can be manufactured. The old filter can be disassembled, the filter paper removed, and the screens washed with gasoline. Replace the filtering agent with any commercial filter paper of the same quality. Place the new filter paper between screens, clip together with paper clips and trim off excess paper. CAUTION: If the paper is too fine, it will interfere with the flow of air and cause improper functioning of the turn indicator.

L-208

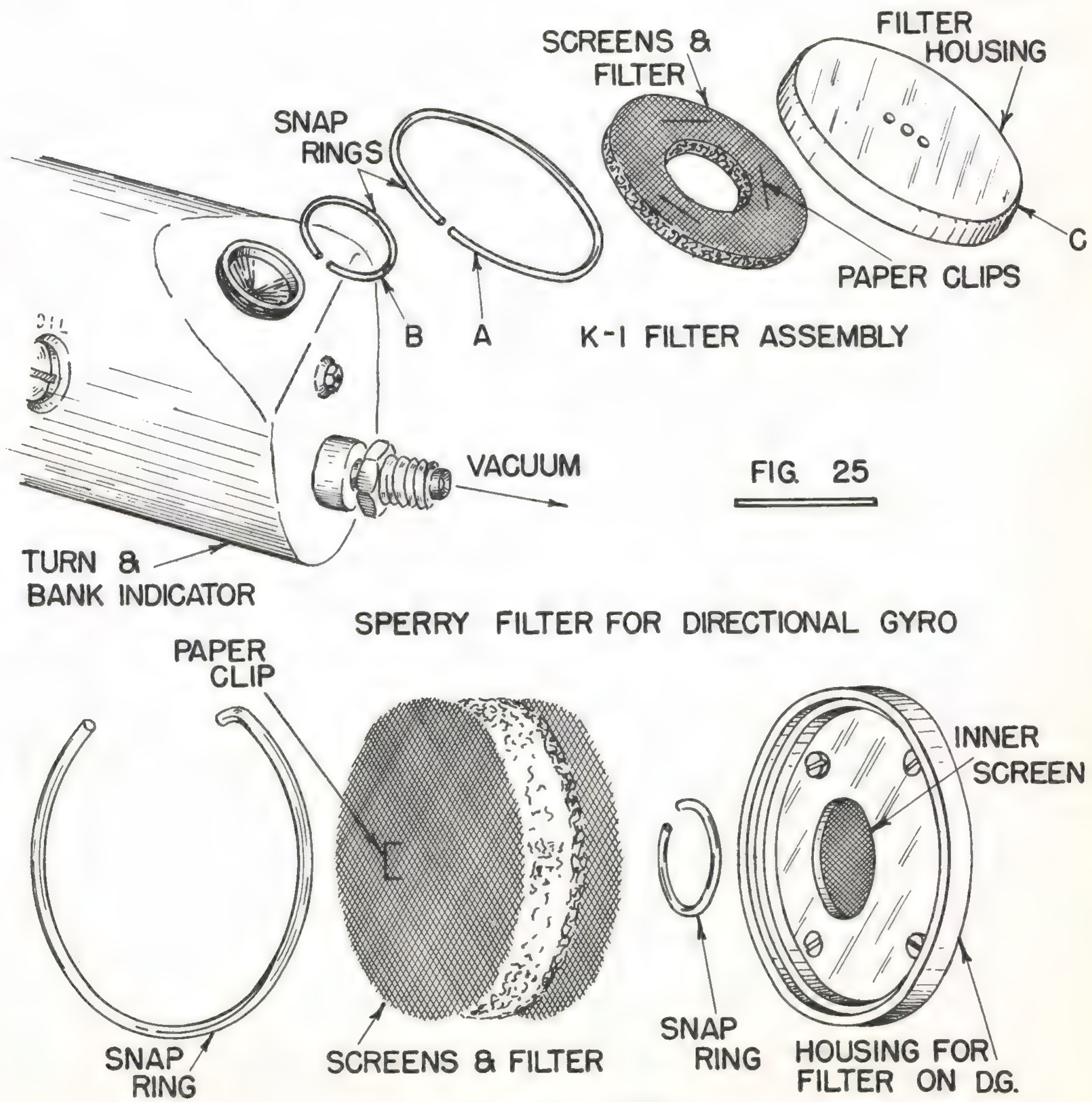


FIG. 25

SECTION VI

ARTIFICIAL HORIZON

This is a special instrument of pendulous control and is not gyro operated like the instrument used in the airplane. When shipped, there are two screws locking its moving parts to prevent damage in shipment. To unlock, it is necessary to remove the rear cover case by loosening knurled nut on end of case. (It is necessary sometimes to remove instrument from panel to be able to remove cover from instrument and to fill small oil dash pots.) Remove the locking screw from the bottom of the instrument, which locks the ball shaped weight (A, Figure 26). Then remove the screw from the rear which locks the lateral control pendulum (B). The instrument is then free to operate. Fill the two small oil dash pots (C and D) with castor oil, using the medicine dropper and oil provided with each Trainer. Work the moving parts until all air is forced from under the dash pot pistons and the dash pot chamber is about 7/8 full of oil. Before replacing the instrument in the Trainer, be sure all moving parts work freely and are not binding or rubbing on adjacent parts.

After installation, it may be necessary to level the indicating bar of the instrument. To do this, remove the cover and shift the position of the sliding brass bar at the end of the instrument (E) until bar is level.

When installation is complete, replace cover to keep out dirt or dust.

L-184

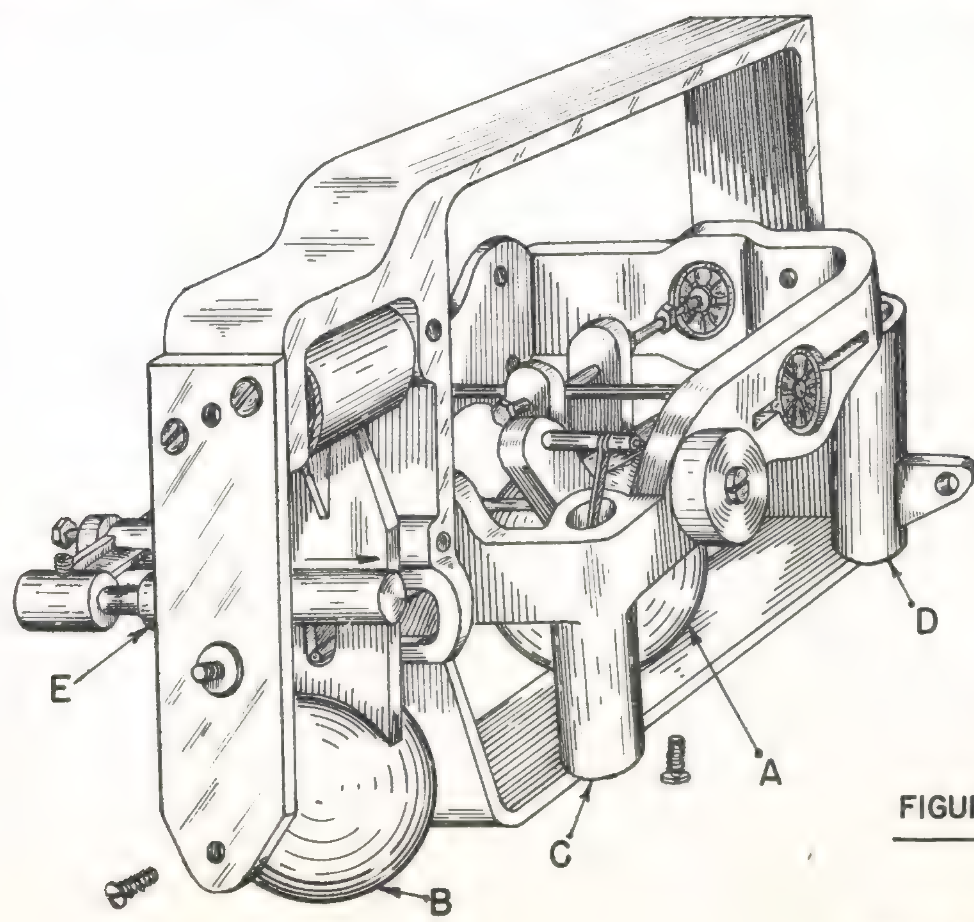


FIGURE 26

SECTION VII

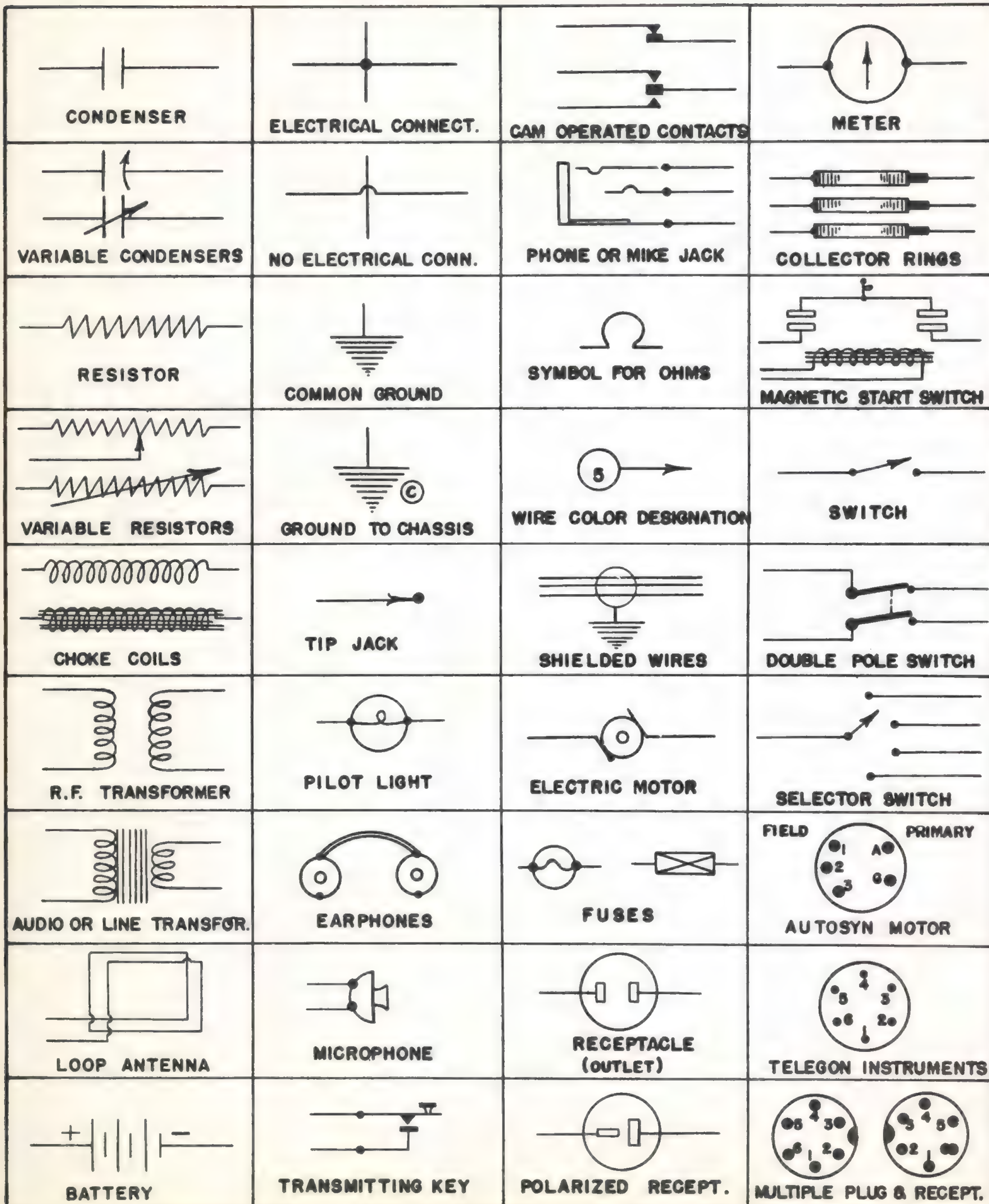
RADIO COMPASS LEFT-RIGHT INDICATOR

This instrument is merely a volt meter with zero in the center and indicates both voltage and direction of flow of current applied to it.

For guidance of the instrument repairman, in making bench tests, the following data is furnished. The instrument is the type utilizing a moving coil in a permanent magnet field. Total resistance is 200 ohms; sensitivity is one volt from zero center. An external mechanical zero adjustment screw is provided on the face.

TABLE OF STANDARD ELECTRICAL SYMBOLS

FIG. 27



C-3 RADIO

General Description

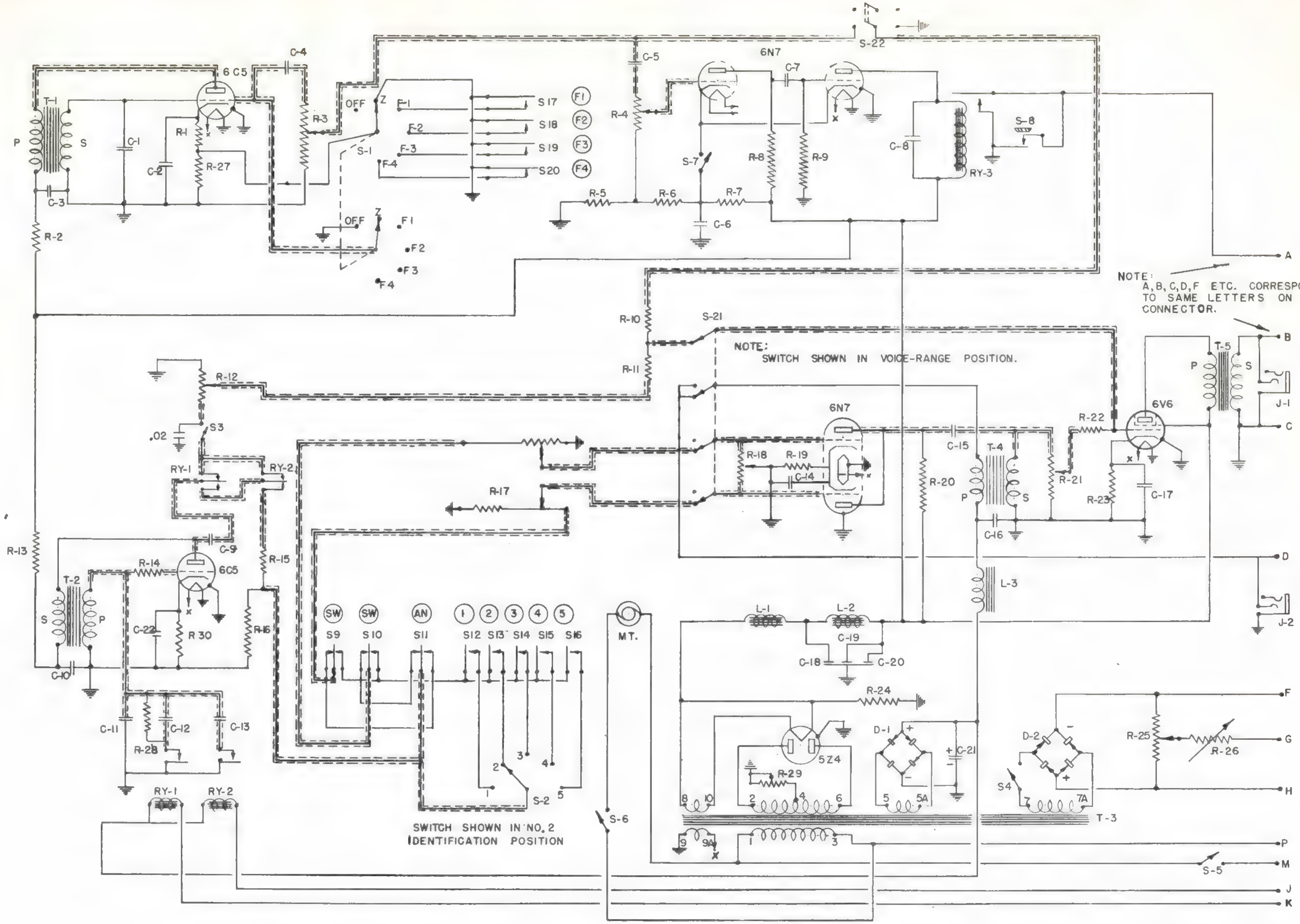
Basically the radio equipment of the C-3 Trainer is similar to that employed in earlier types of Trainers such as the "C" and "E". There is no actual radio transmission employed. Instead, all signals are conducted from the desk to the Trainer over wire circuits. The several audio tones are produced within the control chassis, and after being suitably keyed and intermixed, are amplified and applied to the instructor's and student's headphones. Controls are provided for the selection and control of the various circuits within the control chassis so that range, marker, voice and instrument landing signals may be reproduced to simulate those received in flight. In addition to the aural signals, there are also visual marker signals available. In the cockpit, the student is provided with controls for station selection, radio volume, signaling and the usual control switches for Trainer operation.

Detailed Description

Radio Control Chassis

The circuits of the control chassis (see Figure 27.1) may best be described by separating them according to their function. The power supply section provides the necessary operating voltages for the remainder of the control chassis, the radio compass, the microphone supply and several relays. The power supply section is composed of the following units: a transformer T3, having a primary and five secondary windings as follows: a rectifier filament winding, rectifier plate winding, filament supply winding, mike supply winding and radio compass supply winding. The rectifier tube is a type 5Z4, high vacuum, full wave rectifier which feeds rectified current through a filter system composed of chokes L1 and L2 and capacitors C18, C19 and C20. A bleeder resistor R24 is provided across the output of the power supply section. A.C. voltage from the microphone supply winding is applied to a dry disc rectifier D1. The output current is filtered by capacitor C21, a portion of the current operating relays RY1 and RY2. The remaining current is further filtered by L3 and C16 and applied to the microphone circuit. A.C. voltage from the radio compass supply winding is applied to dry disc rectifier D2. In this instance, no filter is employed, the current being applied to the radio compass circuit directly.

The range oscillator utilizes a type 6C5 tube in conjunction with an oscillation transformer T2. Capacitor C-11 connected across the primary winding forms the resonant circuit, tuning the oscillator circuit to a frequency of 1020 cycles. The oscillator output signal, after going through the contacts of relays RY-1 and RY-2, is applied to a voltage divider network consisting of resistor R-15 and R-16. The signal thence travels from the junction of the two resistors to the range keyer to be keyed as described under keyer operation. The relays RY-1 and RY-2 are controlled by a selector

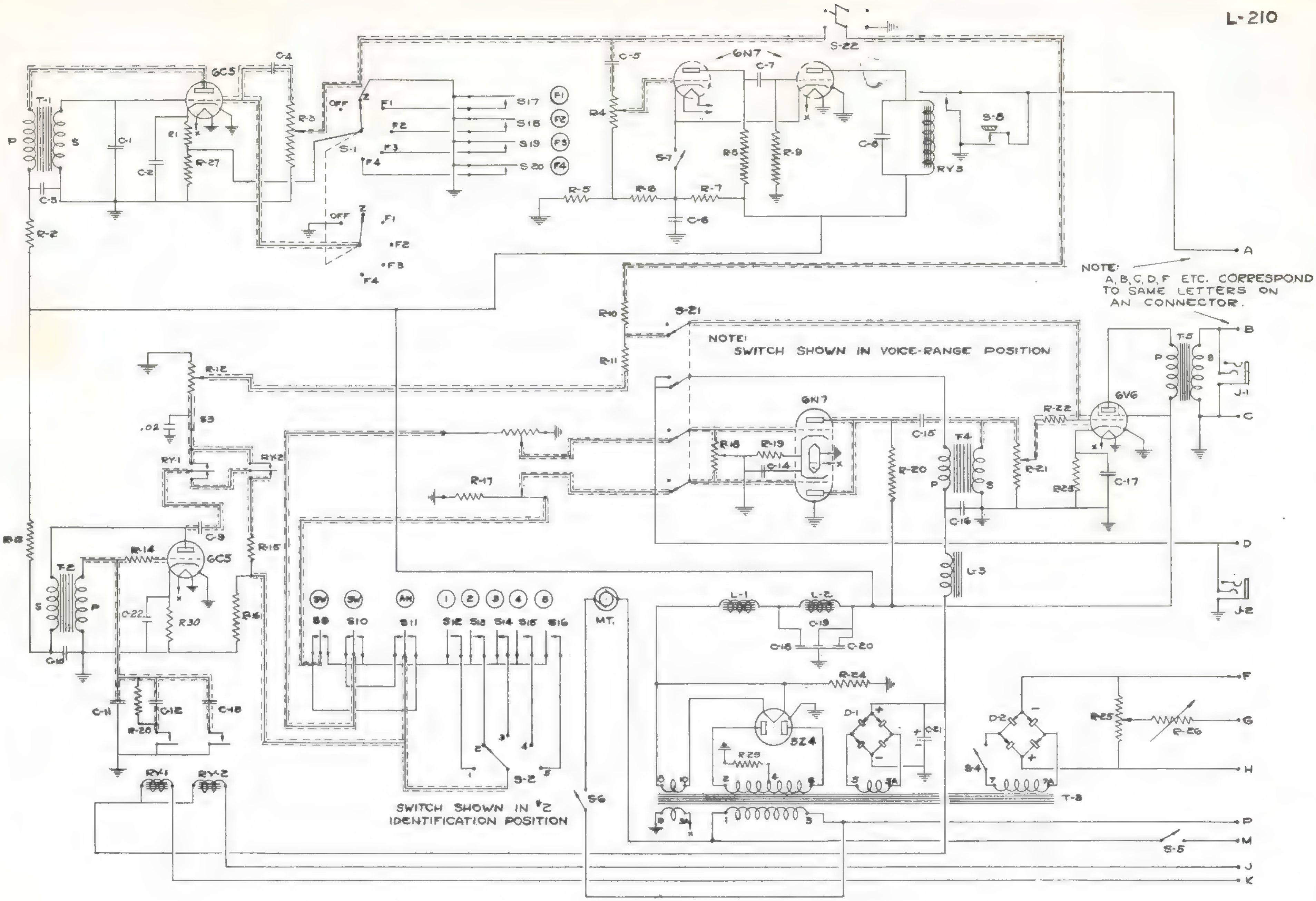


NOTE:
ALL RELAY CONTACTS ARE SHOWN IN NORMAL POSITION.

NOTE
THIS WIRING DIAGRAM APPLIES TO TYPE C-3 LINK TRAINERS BEARING SERIAL NOS. 6000 TO 7999 INCLUSIVE

WIRING DIAGRAM
TYPE C-3 RADIO CHASSIS

FIG. 27.1'



NOTE:
ALL RELAY CONTACTS ARE SHOWN IN NORMAL POSITION.

NOTE
THIS WIRING DIAGRAM APPLIES TO ALL TYPE C-3 TRAINERS, EXCEPT THOSE TRAINERS BEARING SERIAL NOS. 6000 TO 7999 INCLUSIVE.

WIRING DIAGRAM
C-3 RADIO CHASSIS

FIG 27.1
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switch in the fuselage control box. With the switch in the "range" position, neither relay is operated and the signal follows the path described above. With the selector switch in the "outer" position, relay RY-1 is operated and the additional capacity of C-12 is connected across the resonant circuit resulting in a frequency of 800 cycles. Additional contacts on relay RY-1 serve to remove the signal from the voltage divider network and apply it through switch S3 to volume control R-12 and eventually to the grid of the 6V6 amplifier tube. This signal then serves to simulate the outer marker beacon signal of the Air Corps Instrument Landing System. With the selector switch in the "inner" position, relay RY-2 is operated and relay RY-1 is released. With relay RY-2 closed, the capacitor C-13 is shunted across the resonant circuit producing a frequency of 400 cycles per second. Additional contacts on RY-2 complete the circuit through switch S3 and volume control R-12 as before. This signal then simulates the inner marker beacon of the Air Corps Instrument Landing System.

The marker beacon oscillator circuit utilizes a type 6C5 tube in conjunction with an oscillation transformer T-1. Capacitor C-1 shunted across the transformer secondary forms a resonant circuit which produces a frequency of 3000 cycles per second. The output of the oscillator is applied to potentiometer R-3, the setting of which determines the magnitude of the signal output. A portion of the signal is applied through S-22 and S-21 to the grid of the 6V6 amplifier tube. The remaining portion of the signal serves to operate the 6N7 relay tube in such a manner that each signal pulse closes relay RY-3. The relay in turn closes a circuit to an indicator lamp on the instrument panel thus giving visual indications of the marker beacon signals. A switch S-7 is provided for the purpose of removing visual signals if desired while a push button switch, S-8, enables the instructor to give additional visual signals other than those provided.

The output of the keyer is applied to the beam shift control R-17 and thence to the grids of the 6N7 mixer tube. The output circuit of the mixer tube is capacitively coupled to the voice-range volume control R-21. The microphone transformer is also connected across this same control, the combined voice and range signals being applied to the grid of the 6V6 amplifier tube. The output circuit of the 6V6 amplifier tube consists of a transformer which couples the tube output to the headphones in the desk and the fuselage.

Fuselage Control Box

The following controls are provided on the fuselage control box: radio volume, for controlling the radio signal level in the earphones; station selector, for selecting either range, inner or outer marker stations; radio compass sensitivity; call switch and cockpit light dimmer. Within the control box are also located two transformers which supply current for the fluorescent lights. Two additional transformers are also provided, one supplies current to the marker lamp while the other provides current for the compass deflector as well as the call signal switch. The compass deflector rectifier and adjustable resistor are also located in the fuselage control as are the headphone and microphone jacks.

L-163

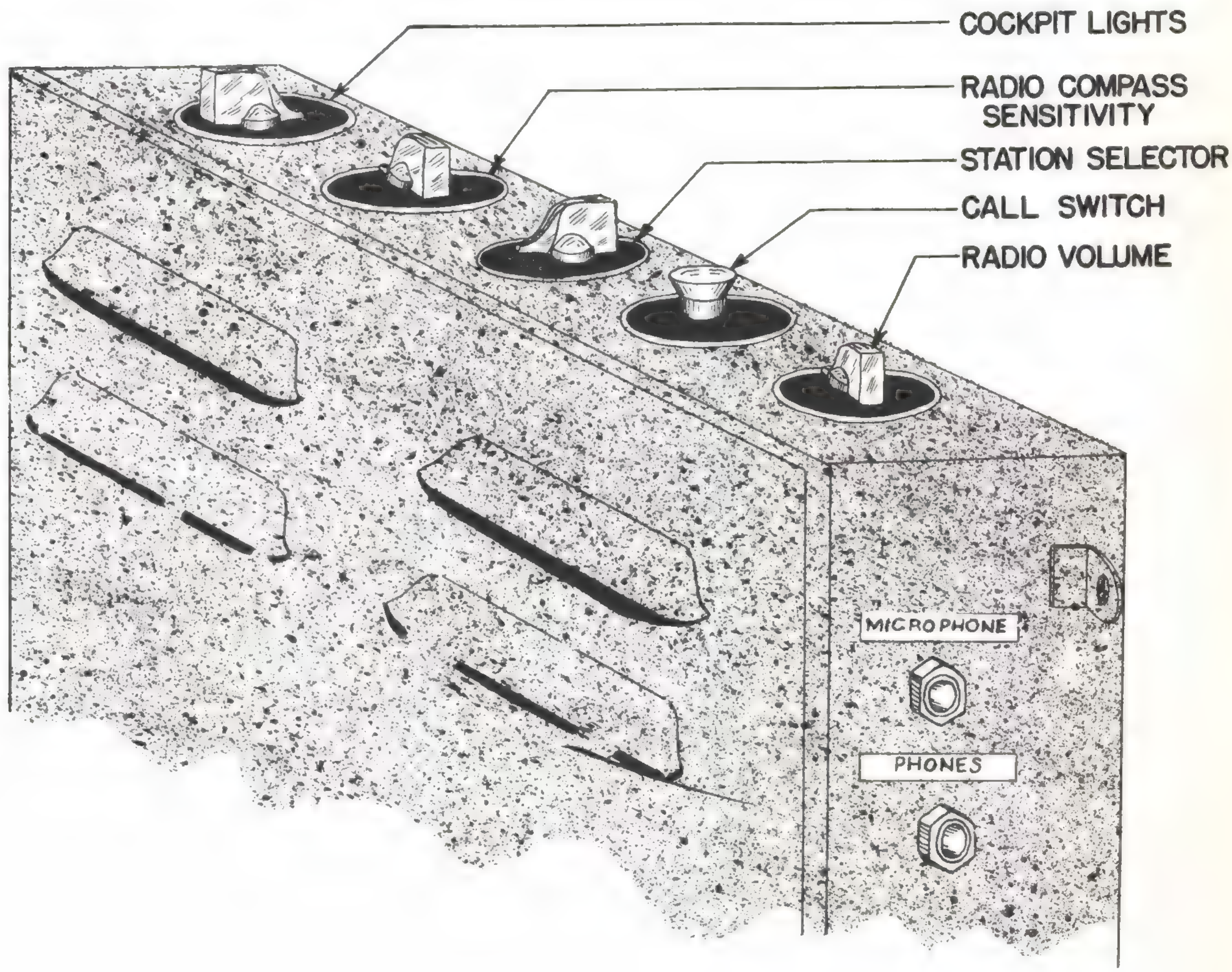


FIGURE 28

SECTION II C-3

RADIO RANGE KEYER

This device automatically produces A-N signals, fan markers, and station identification signals.

The main cam assembly with its several pairs of call letters may be replaced in a few seconds with an assembly providing entirely different letters.

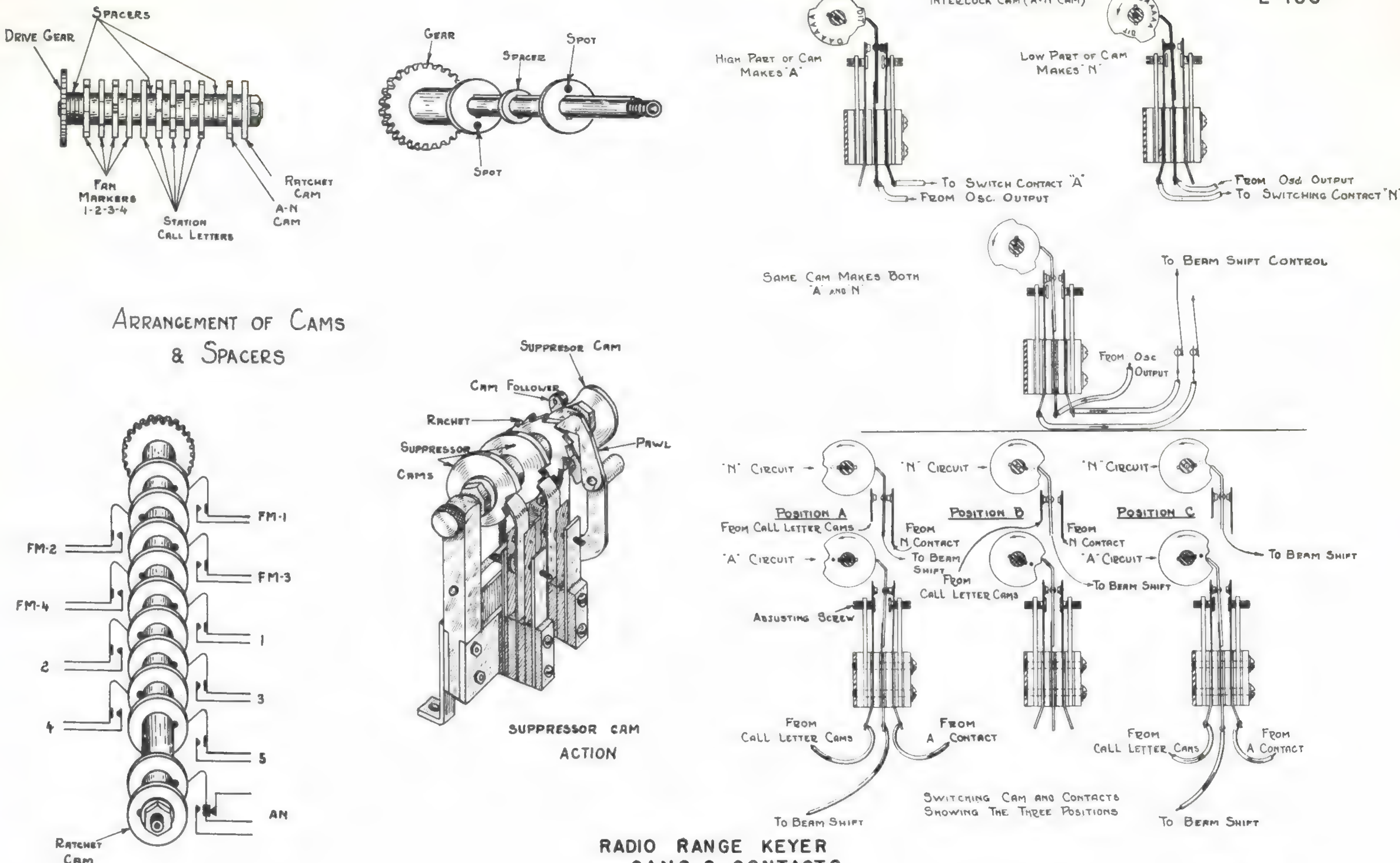
The gearing of the cam shaft is selected according to the type of current specified with purchase. The motor is a constant speed type and requires no adjustment.

Automatic Operation of Keyer

The purpose of the Keyer is to take a steady tone which is produced by the Trainer radio and break it up into A's and N's, station identification letters, and marker signals.

The steady note, or signal, is given a choice of routes from inside the control chassis to the keyer and back again into the control chassis. This signal is made to produce A's and N's, when routed one way, and identification letters when switched through the other routes.

A's and N's are produced by one cam and three contacts. Two of the contacts are fixed and the middle one is actuated by the cam. The high parts of the cam press the movable contact against the outer of the two fixed contacts and produces A's while the low parts of the cam produce N's in the same manner from the inner fixed contact. The points are so adjusted that the movable contact is making connection at all times either with the outer or with the inner fixed contact. Thus the dit of the A fills the space between the dah and dit of the N and the dit of the N fills the space between the dit and dah of the A. Thus, when the signals produced by both sets of contacts are heard with equal intensity, a continuous monotone results. The current for the A's and N's leaves the "beam oscillator" circuit of the radio chassis on a wire which connects to the middle (movable) contact of the A-N cam. This cam presses the movable contact alternately against the two fixed contacts in such a manner as to produce A's and N's. These contacts are adjusted so that the moving one makes contact with one of the fixed points at the same instant it breaks contact with the other. Thus, there is no overlap, yet current is flowing continuously through either one or the other. From the keyer A-N contacts the current travels back to the A-N mixture control where the A's and N's are blended into various radio range characters, as explained in the radio description.



RADIO RANGE KEYER
CAMS & CONTACTS
FIG.-29

AUG. 1, 1941

The "on course", or series of 12 A-N interlocks, occupies approximately thirty seconds. In other words, the A-N cam is in operation for thirty seconds and then it is interrupted electrically while two sets of station identification letters are sent.

This is accomplished by the switching cam assembly on the right hand end of the keyer. Two cams and two sets of contacts are provided on this assembly, driven by a ratchet and ratchet cam assembly, which advances one notch with each revolution of the main cam assembly. These sets of contacts interrupt the A and N current supply and switch the current through the station identification cam contacts instead of through the A-N contacts.

During the thirty seconds of the A's and N's, these points are closed as in position A, Figure 29 . At the end of the thirty second period, both contacts are opened, thus interrupting the current to the A-N cam contacts. At the same time the contact in the N circuit of the switching cam contacts is permitted to move far enough to make contact with the fixed contact, position B in Figure 29, which is connected to the common wire connecting the station identification cam contacts during one revolution of the main cam assembly. The station identification is thus transmitted to the N side of the mixture control. The ratchet then advances the switching cams another notch, which allows the movable contact on the A circuit as in position C, to make contact during the next revolution of the main cam assembly. The station identification call is repeated and transmitted through the A side of the mixture control. With the next notch moved by the ratchet the cams push the contacts back to their original position, making the circuit complete again on the A-N cam contacts.

Five different station identification calls are provided. The same tone used for A-N signals is used for station call letters but is handled differently. Through a selector switch located on the control chassis, any one of the 5 stations may be selected.

Removing and Replacing Cam Assemblies

If spare main cam shaft assemblies are available to provide additional station calls, the change can be made in a few seconds. Simply unscrew the knurled nut on the end of the cam shaft bearing pin and pull it out about two thirds of the way. (This shaft has a LEFT HAND THREAD - Turn RIGHT to remove.) The shaft should be pulled out only far enough to clear the main cam assembly, without releasing the switching cams. While pulling out the pin shaft, hold the main cam assembly with one hand and lift it out as the pin shaft clears it. In replacing the unit, ease it into place carefully so as not to damage the cam followers or contacts. No timing is necessary as this is taken care of in the main cam assembly.

FAN AND "Z" MARKERS

Keying of the Fan Markers is arrived at differently than in the method of keying A's and N's and station identification calls. Instead of keying the oscillator output, the keyer contacts close the circuit of a high resistance (R-27) Figure 27.1 to ground, which starts the oscillation of the marker circuit. This manner of keying eliminates the undesirable "key clicks" of the fan marker contacts.

The fan marker cams are cut differently for proper coding of radio signals.

Different characters for the four fan markers and "Z" marker are obtained on the five position selector switch.

When the selector switch is in the "Z" marker position the circuit is continuously closed and the high frequency resistor (R-27) Figure 27.1 circuit is shorting to ground allowing oscillation to take place in the marker oscillator tube as long as the switch is closed.

Shielding

The main output for all circuits including mixture control and keyer A-N circuits are shielded to prevent induction of signal and insure minimum interference between the various circuits.

SECTION III

RADIO COMPASS

This instrument on the Trainer is not controlled by radio but is designed merely to simulate the Radio Compass for the Trainer. The indicating instrument is a voltmeter which indicates with right or left movements of the pointer according to the polarity (+ or -) of the current. The current to operate the Radio Compass is rectified A.C. of 10 Volts. This is obtained from a secondary winding of the power transformer in the desk power supply. The control unit is on top of the automatic Recorder (Figure 30.1). This consists of two resistance units and a movable contact which moves as the Trainer heading is changed. The wiring is connected in such a manner (Figure 30) that when the movable contact is exactly in the center of one of the resistance units, no current flows. The moment a slight turn is made to right or left, current flows proportionately positive (+) or negative (-) to the meter causing an indication to register to right or left. The resistance unit is actually two units set 180 degrees apart so that the same action takes place when headed in the opposite direction, except that the needle of the indicator swings in the opposite direction the same as in the actual Radio Compass in flight.

Adjustment

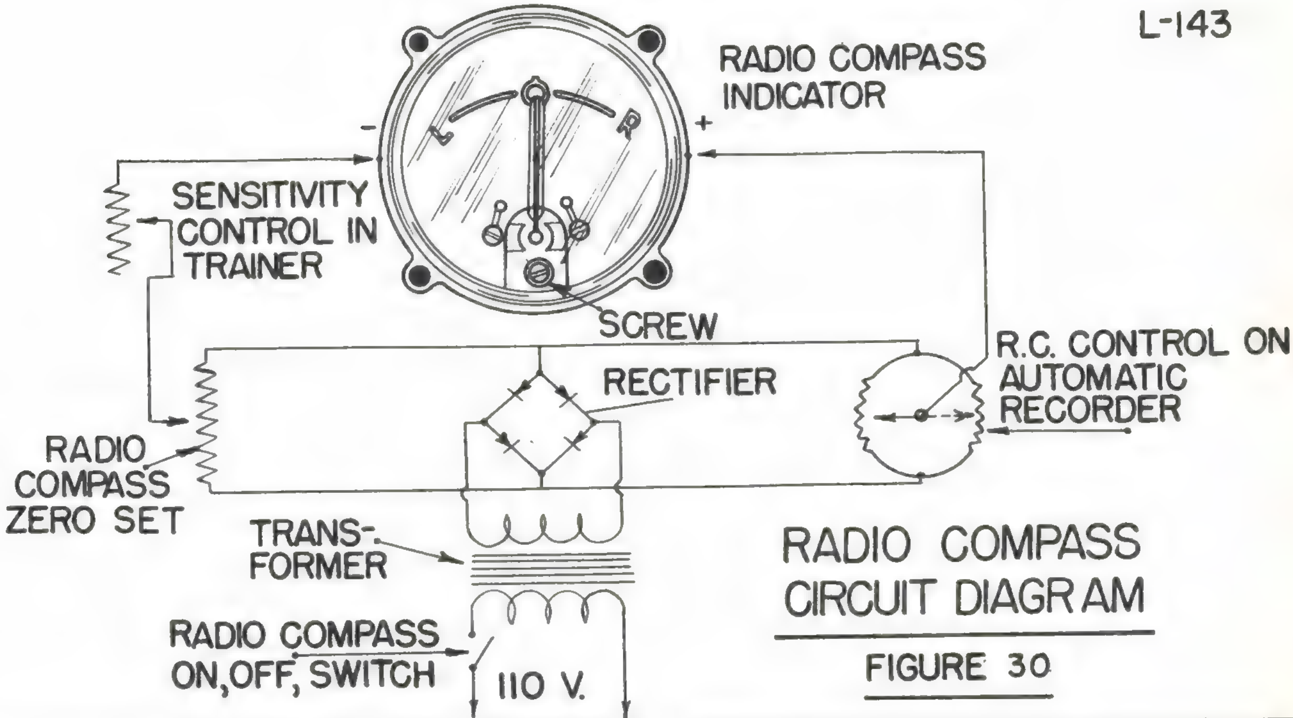
There are three adjustments on the Radio Compass: one, centering of the indicator pointer by adjusting the small screw located on the face (see Figure 30); two, the headings on which the needle will center without moving the dial must be exactly 180 degrees apart; three, the right-left indicator must be centered when the movable pointer ("B" in Figure 4) is over the zero on the rotating dial.

If necessary to make these adjustments, before adjusting the radio compass control unit, check for centered pointer of the indicator with the current off. Turn on the main switch in the Trainer, so the recorder teletorque will be alive if the pointer is not centered. Then remove pointer "B". Remove three small screws ("D" in Figure 4) and lift off movable cover. Turn the Trainer by hand until, with full volume on, the L-R indicator needle is exactly centered, with the wiping brush ("A" in Figure 30.1) in contact with the <u>lower</u> of the two resistor discs ("B"). Then, being careful not to disturb the Trainer, rotate the large recorder gears through six "electric notches". Now, loosen the large nut "C" that holds the two discs, and rotate the <u>top</u> disc "D" slightly one way and the other (being careful not to disturb the <u>lower</u> disc) until the L-R needle is again exactly centered. Tighten the nut and recheck on both headings then replace the dial and pointer.

To obtain the second adjustment, leave the Trainer main switch on and make sure the pointer "B" is pointed in exactly the same direction as the inking wheel. Next, rotate the dial until the zero is exactly under the pointer. Now, <u>being very careful not to disturb either the rotatable dial or the Trainer</u>, remove the pointer

"B" and the three screws that hold the cover in place and carefully lift off the cover. Loosen the small special nut that holds brush "A", meanwhile holding the large recorder gear from turning. Move the brush until the L-R needle is exactly centered and tighten down the special nut. Replace the dial, with the zero pointed in the same direction as the inking wheel, and replace the pointer exactly over zero.

L-143



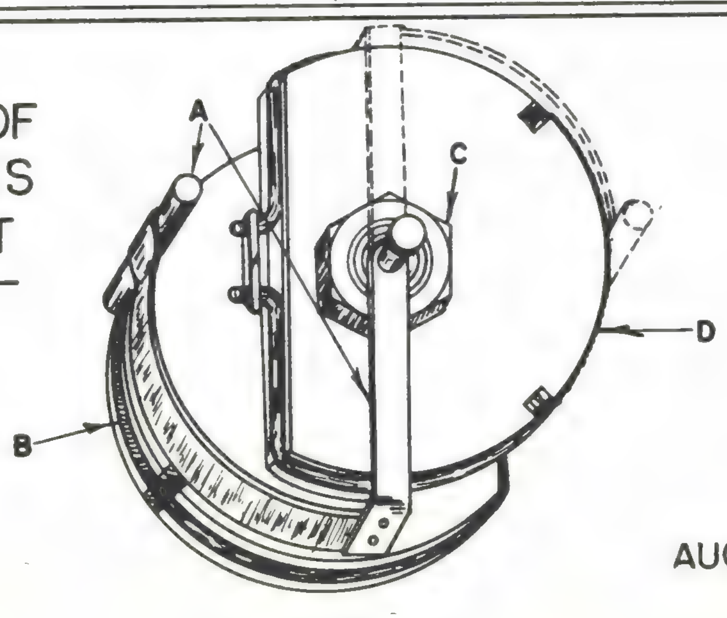
RADIO COMPASS CIRCUIT DIAGRAM

FIGURE 30

L-144

ADJUSTMENT OF RADIO COMPASS CONTROL UNIT

FIGURE 30.1



AUG. 1, 1941

SECTION V

REMOTE INSTRUMENTS

General Description

The Kollsman Telegon System of remote indication is used on the Link Instrument and Radio Pilot Trainer in order to have identical instrument readings on duplicate sets of instruments, one of which is located on the instructor's desk and the other on the instrument board of the Trainer fuselage.

The remote indicating system consists of a single transmitting unit, located at the source of measurement, and two indicating units, one of which is mounted on the instrument board of the Trainer's fuselage, and the other at the instructor's desk. The transmitter is a Kollsman Telegon unit which is actuated by an instrument mechanism similar to standard instruments. The indicator consists of a Telegon unit which is structurally identical with the transmitter unit and which carries the instrument dial and hand.

The external wiring of the Telegon system is shown in Figure 31 and the internal wiring connections are shown in Figure 32.

Figure 33 is a top view of a Telegon unit with the end bells and case removed showing the arrangement of the terminals. This unit is inclosed in a steel shell and aluminum end bells, which complete the case, are held by four brass clamp screws. Figure 34 is a cross-sectional view of a Telegon unit. The unit consists of a spool assembly, four terminals and two terminal insulators, the shell and two end bells. The spool assembly contains the shaft assembly K, the primary coil M, and the phase windings F-F'. The four terminals are connected to the primary coil and the phase windings.

Operation

The primary coil M (See Figure 33) is energized from an external alternating current source, the flux magnetizing the center section of the shaft assembly K and the vanes. The magnetic circuit is completed through the outer shell S. When the shaft assembly of the transmitting unit is rotated, the induced magnetic field surrounding the vanes is also rotated. This field pattern induces a voltage in the phase windings (F-F'), the voltages being proportioned according to the geometric alignment of the flux to the phase windings. The voltages thus induced give rise to proportional currents which flow in the phase winding circuits of both the transmitting and the indicating units, setting up a flux pattern in the indicating unit identical to the

pattern in the transmitting unit. The field flux in the indicating unit reacts with the vanes (which are magnetized from the same source as the transmitting unit), causing the shaft assembly to assume the same angular position as that of the transmitting unit.

If afforded proper care and handling the Telegon system will function almost indefinitely. Under no circumstances should the actual Telegon unit be removed from its case or disassembled unless there is a definite indication that the trouble is located in the unit. If trouble should develop it will usually be found that the fault lies in the electrical cables connecting the transmitting unit to the indicating unit.

L-189

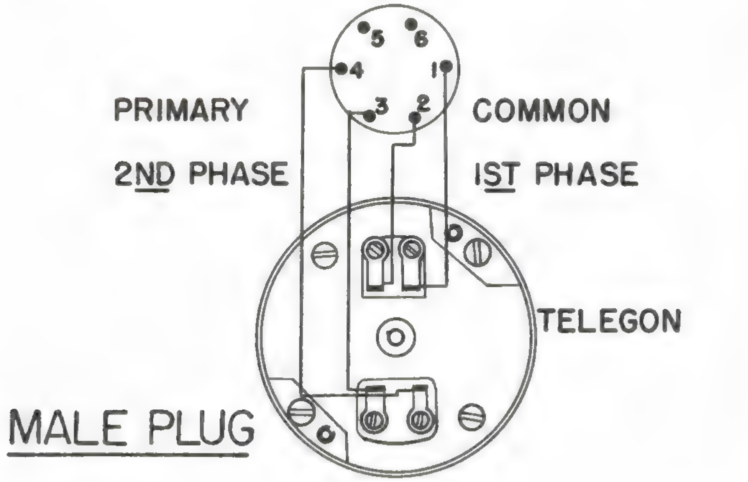


FIGURE 32

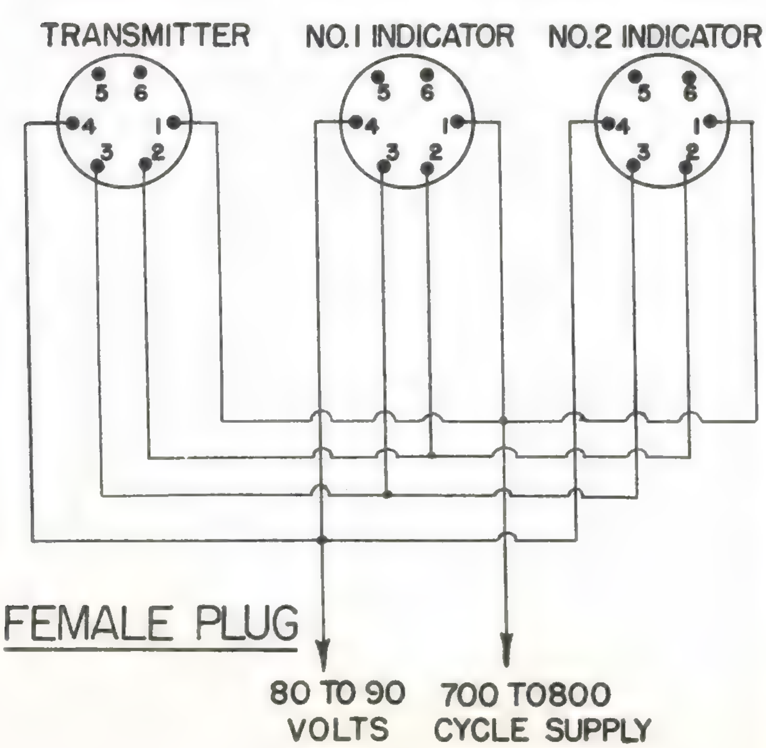


FIGURE 31

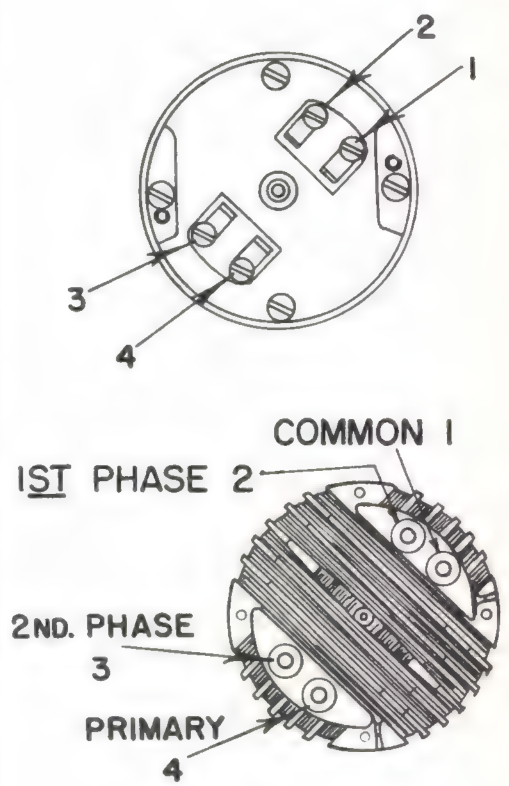


FIGURE 33

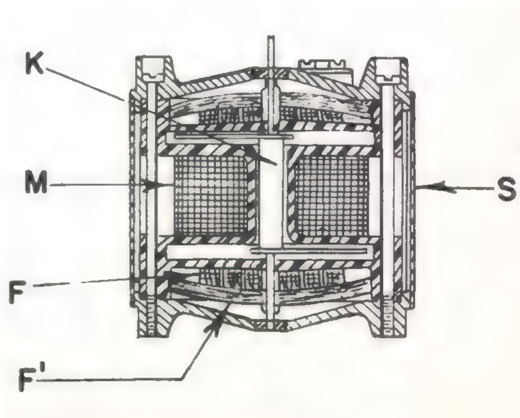


FIGURE 34

SECTION VI

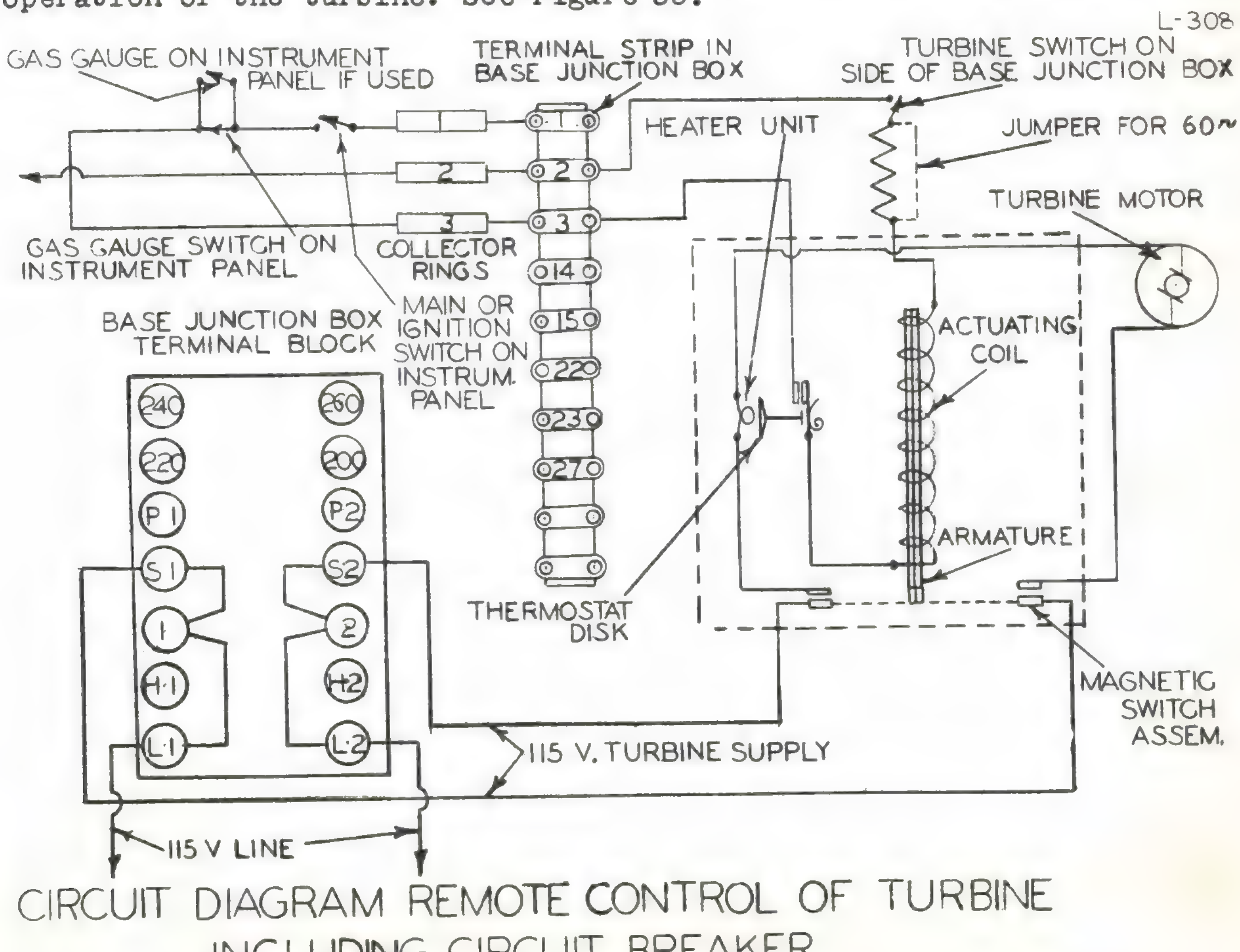
VACUUM TURBINE AND MOTOR

The vacuum supply in the Trainer is obtained by the use of a turbine type blower with a capacity of approximately 12 cubic feet per minute at 4-1/2 inches of mercury. It is driven by an electric motor and is mounted directly on the armature shaft of this motor.

The motor is a 3/4 horsepower, Universal type, which will operate on either direct or alternating current. In this type of motor, some sparking normally occurs at the brushes. Normal operating temperature of the unit is around 150 degrees Fahrenheit; temperatures of 200°F. will do no harm. See also Chapter VI, Section VI.

CIRCUIT BREAKER

The purpose of the circuit breaker (Magnetic Switch), which is located in the base terminal box, is to protect the turbine motor in case of an overload. If an overload exists in the turbine circuit, a bi-metallic disc is heated by a heater unit which expands the disc and opens the circuit of the actuating coil. This releases the armature of the coil, causing the breaker points to open the turbine circuit. When the bi-metallic disc cools sufficiently to close the contacts controlling the actuating coil, the breaker contacts are again closed. This completes the circuit to the turbine motor, thereby resuming normal operation of the turbine. See Figure 35.



CIRCUIT DIAGRAM REMOTE CONTROL OF TURBINE INCLUDING CIRCUIT BREAKER

FIGURE 35

JAN. 1, 1942

SECTION VII

ELECTRIC COMPASS DEFLECTOR

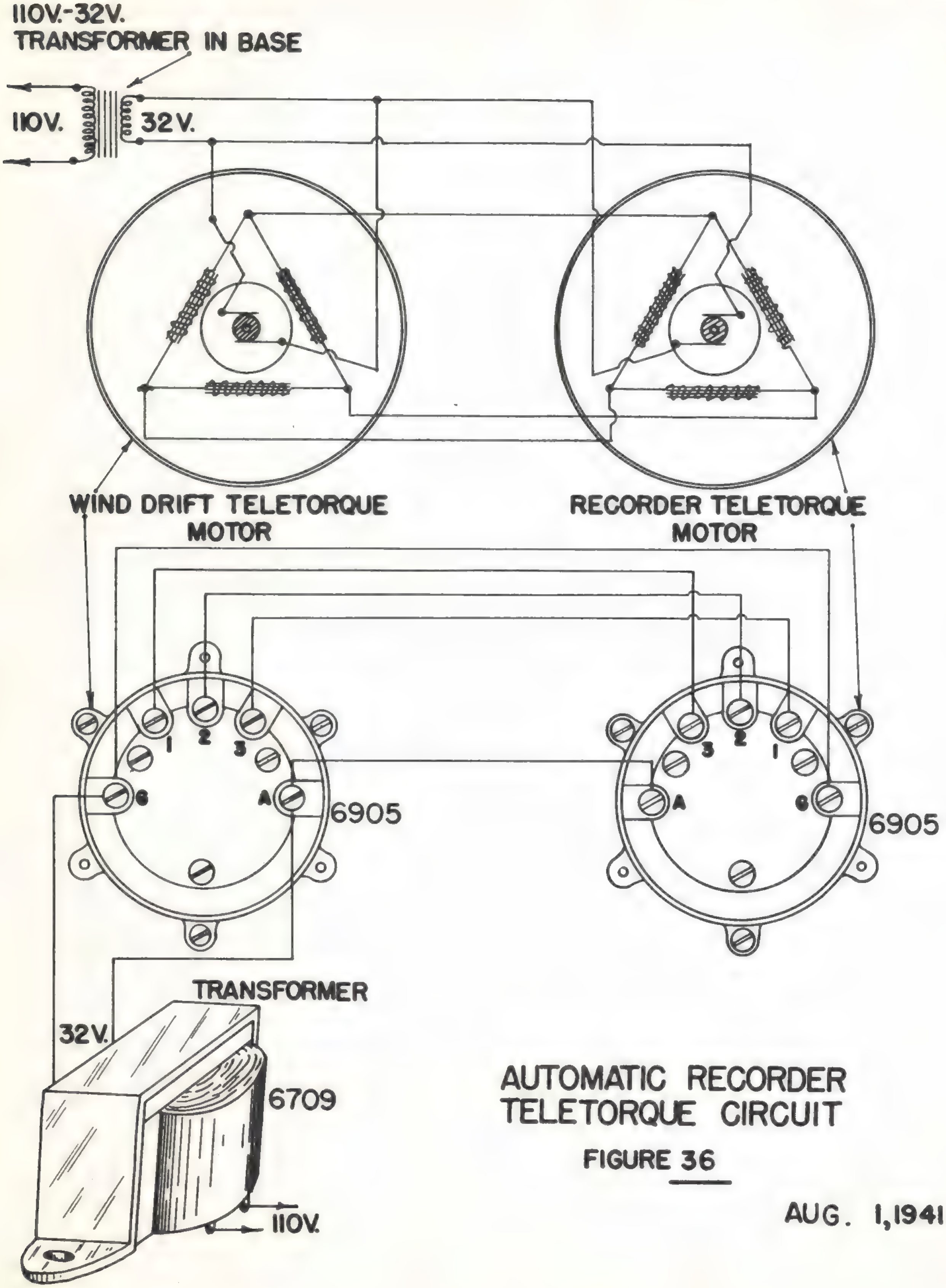
The compass in the Trainer is a standard aircraft instrument, but due to lack of centrifugal force during turns, no Northerly Turning Error occurs. It is therefore necessary to introduce a device which will cause the compass to simulate this turning error.

A small electro-magnet is mounted directly under the compass. Current is supplied through a set of contacts mounted on the rudder valve. (See Figure 46.1)

These contacts consist of two fixed contact plates attached to the lower, fixed half of the valve, and a third contact attached to the top, movable part of the valve. When a left turn is started, the moving contact closes the circuit through one of the fixed contact plates and current flows through the coil of the magnet in one direction; when a right turn is started, the other fixed plate carries current through the coil in the other direction. The direction of flow of current determines the direction of compass swing.

Power is obtained from the 12 Volt A.C. transformer which is located in the fuselage control box mounted in the cockpit of the Trainer. This current is rectified by a dry disc rectifier to provide direct current for the electro-magnet.

This current passes through a resistor with an adjustalbe sliding contact so that the current and amount of compass deflection may be set to the desired value. The resistor is located in the fuselage control box.



AUTOMATIC RECORDER
TELETORQUE CIRCUIT

FIGURE 36

AUG. 1, 1941

SECTION VIII

RECORDER SYSTEM
and
DRIVING MOTORS

Directional control of the Recorder (also see Chapter II, Section 11) is obtained through the use of two synchronous motors. Figure 36 shows the electrical hook-up. It is a characteristic of these motors that when the proper power (50 cycle or 60 cycle 32 V) is applied to the armature circuit, the motor which is free to turn (in the Recorder) will align itself with the other motor (in the base, geared to Trainer main shaft).

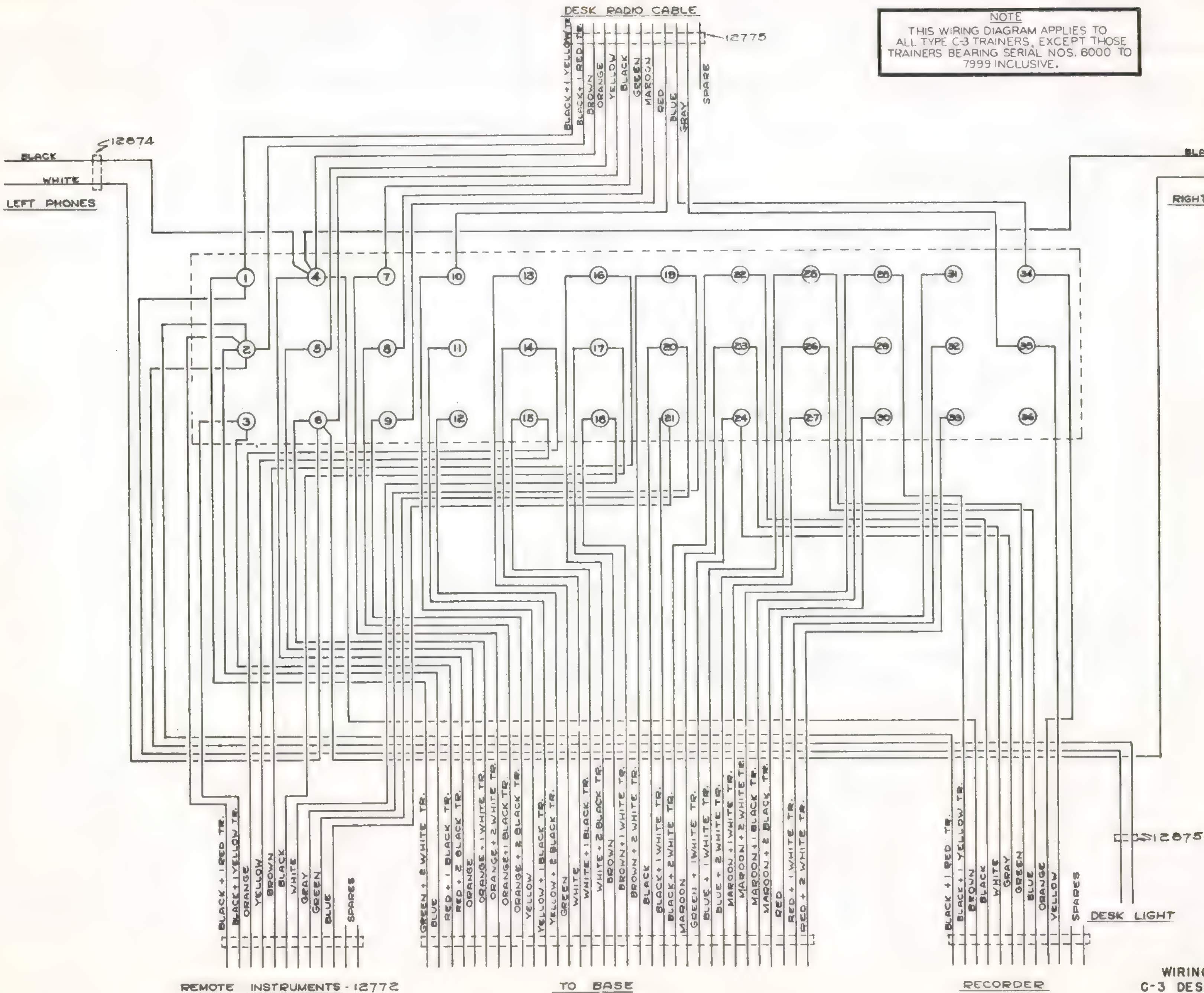
Power applied to the armature circuit induces a "field" in the field windings. When the Trainer turns and, through gears, rotates the "motor" in the base, the electric "field" is also rotated. The field windings of the motor in the Recorder are connected by three wires to the base motor and its field is also revolved in phase with the one in the base. As the field in the Recorder motor is rotated, the armature rotates with it, thus keeping the Recorder motor at all times aligned with the one in the base.

The two driving motors are a synchronous, constant speed type and operate on 110 volt, 50 or 60 cycle current. On 60 cycles the armatures turn 3600 R.P.M., and on 50 cycle, 3000 R.P.M. This speed is greatly reduced by gears within the motor assembly and further reduced by the brass external driving gears to the desired tracking speed. This enormous gear reduction should make clear that these motors must not be turned by hand.

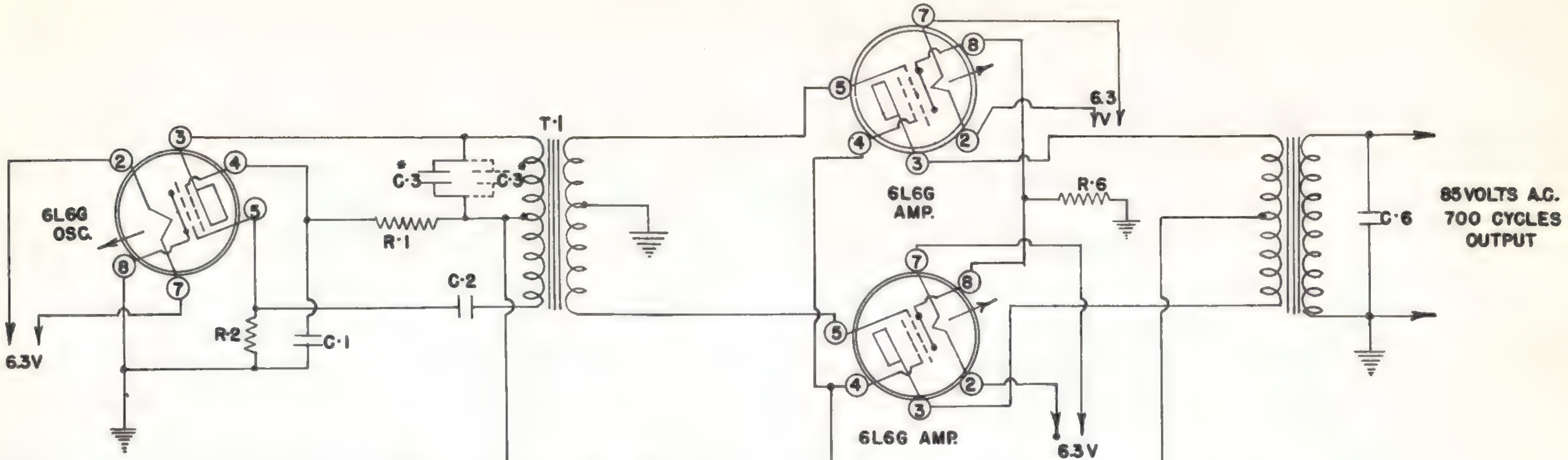
Because of the gear train, low temperatures will cause the motor to run irregularly and the Recorder will then not track properly.

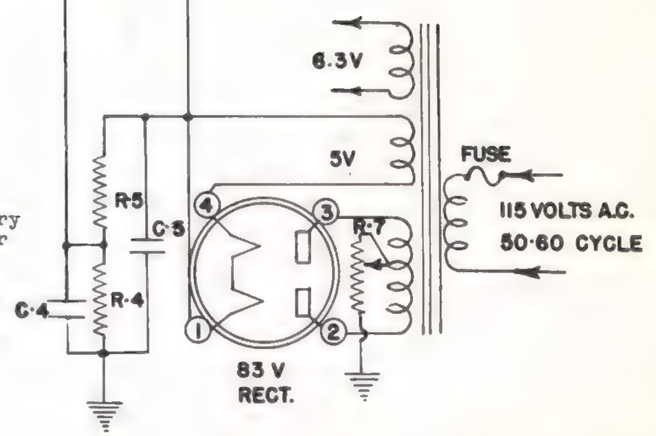
Current is brought to each Telechron motor through a pair of slip rings. These rings must be clean and the brushes making good contact.

NOTE
THIS WIRING DIAGRAM APPLIES TO ALL TYPE C-3 TRAINERS, EXCEPT THOSE TRAINERS BEARING SERIAL NOS. 6000 TO 7999 INCLUSIVE.



WIRING DIAGRAM
C-3 DESK JUNCTION BOX
FIG. - 58





TELEGON OSCILLATOR TEST DATA

These Voltage tests must be made with exactly 115 Volts input to the Oscillator, with all instruments properly connected. During normal operation, voltages should not vary more than ± 5%. Voltage of more than 10% should be carefully investigated.

Normal working voltages between Tube elements and ground

Ocillator Tube

Prong	#3 to ground,		220	Volts	D.C.
"	#4 "	"	65	"	"
"	#5 "	"	-28.5	"	"
"	#2 "	#7	6.3	"	A.C.

Amplifier Tubes

Prong	#3 to ground,		345	Volts	D.C.
"	#4 "	"	220	"	"
"	#5 "	"	0	"	"
"	#7 "	"	6.3	"	A.C.

Rectifier Tube

Prong	#1 to ground,		355	Volts	D.C.
"	#2 "	"	315	"	A.C.
"	#3 "	"	315	"	"
"	#2 "	#3	690	"	"
"	#1 "	#4	4.9	"	"

Resistance between Tube elements and ground. Oscillator OFF

Oscillator Tube

Prong	#3 to ground,		200,000	ohm
"	#4 "	"	700,000	"
"	#5 "	"	400,000	"

Amplifier Tubes

Prong	#3 to ground,		210,000	ohm
"	#4 "	"	200,000	"
"	#8 "	"	500	"

One End of Resistor R7 to ground, 0; other end to ground, 35 Volts D.C. with Oscillator on.

NOTE:- C-3*
This capacity is adjusted at the factory to tune the Oscillator Frequency to between 700 and 800 cycles. This is a combination of two condensers, the combined capacity of which may vary to as much as .09 MFD.

Condensers		
C1;	.05	MFD- 1000 V.
C2;	.001	" - 400 V.
C3;	.05	" - 1000 V.(paper)
C4;	16.	" - 450 V
C5;	4.	" - 1000 V.(oil)
C6;	1.	" - 600 V.

Resistors			
R1;	500,000 ohm,	1	Watt
R2;	400,000 "	1	"
R4;	200,000 "	1	"
R5;	10,000 "	25	"
R6;	500 "	50	"
R7;	500 "	50	"

LINK TELEGON OSCILLATOR WIRING DIAGRAM

FIGURE 37

AUG. 1, 1941

SECTION IX

TELEGON OSCILLATOR
for
REMOTE INDICATING INSTRUMENTS

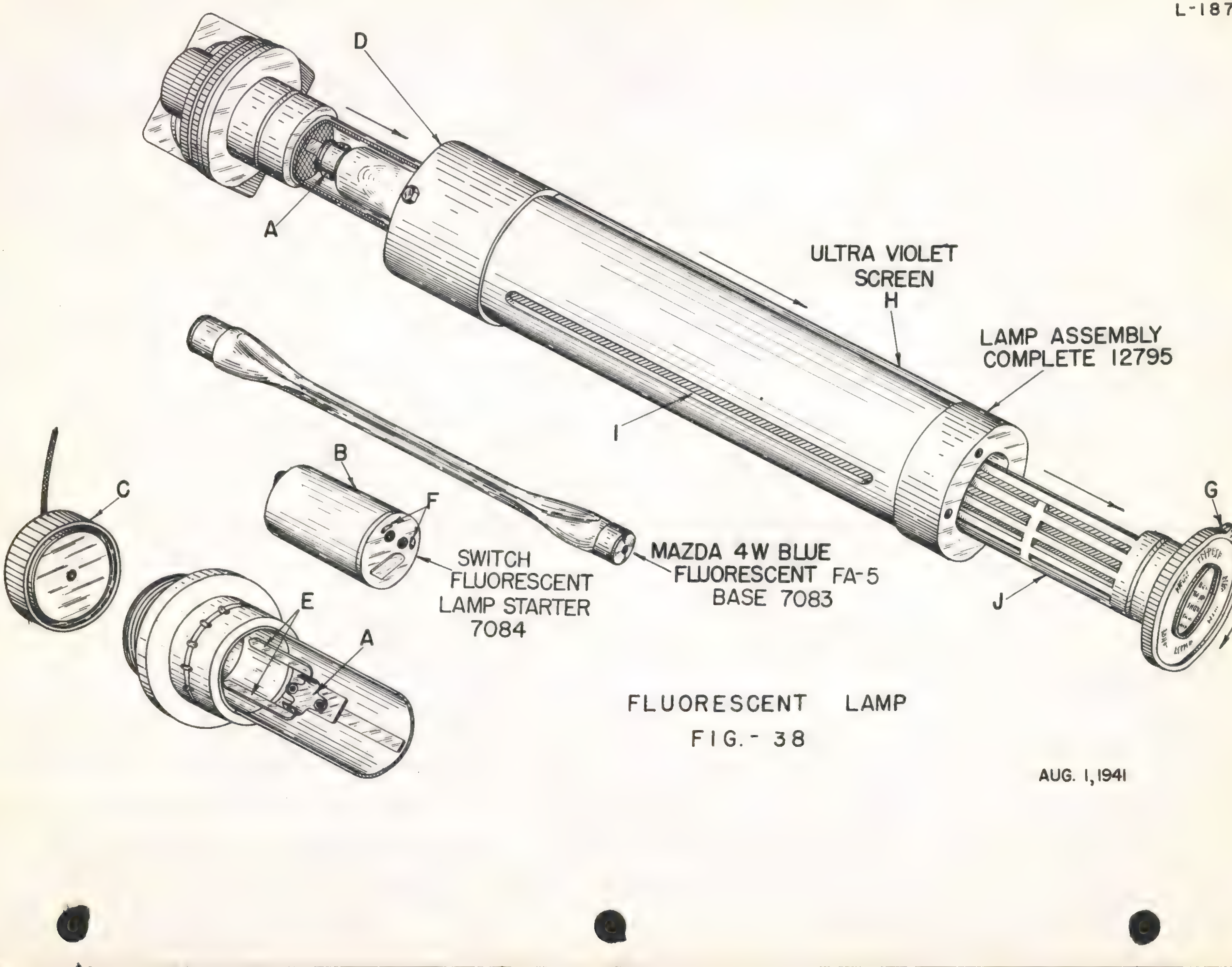
The function of this unit is to supply 700 to 800 cycle current for the remote indicating instruments. It utilizes a type 83V rectifier tube; and three 6L6G tubes; one as an oscillator and the other two as amplifiers to increase power to the necessary level for proper operation of the instruments.

Power supply to the Telegon Oscillator should be 110 to 115 volts, 50 cycle to 60 cycle frequency. The output of the unit should be 80 volts to 90 volts, 700 to 800 c.p.s. The voltage must be measured under full-load condition (all remote instruments properly connected). Voltage can be regulated by adjustment of the sliding contact on resistor R7 (see Figure 37).

If a suitable meter is not available, the 700 to 800 cycle frequency may be checked by touching <u>one</u> tip of a pair of headphones to one side of the output and comparing the tone with any source of a 700 to 800 c.p.s. note such as a tuning fork or some musical instrument. The frequency may be adjusted by slight changes in the capacity of condenser C3.

On rare occasions it has been necessary to vary the value of condenser C-6 from as little as .5 to as much as 1.5 mfd. to obtain the correct output. This change should not be made, however, until everything else is proven perfect.

FLOROESCENT LAMP



FLUORESCENT LAMP

FIG. - 38

AUG. 1, 1941

2 – 25 VOLT .2 AMP. SINGLE CIRCUIT

SECTION X

INSTRUMENT LIGHTS, TRANSFORMER AND RECORDER LIGHT

The instrument lights use 12 Volt 6 cp double contact bulbs. Current is obtained from the 110 Volt, 12 Volt transformer, located in the control box in the Trainer cockpit. Should it be necessary to trace the wires, it should be remembered that the current for the left hand light is conducted into the door through the door hinges.

FLUORESCENT LIGHT

Fluorescent light is used to activate the luminous dials of the instruments. A power supply of 110 Volts for each lamp is obtained from two transformers located in the bottom of the cockpit control box. Bulbs for these lamps are the 4 Watt size. Should it be necessary to change the bulbs or remove them for any reason, dismantle the lamp assembly by pulling the bakelite case off from the base, as shown in Figure 38. To remove, pull the bulb out of the clip fasteners (A) on each end of the bulb. When removing, it is necessary to unsnap the bottom clip first. Insert new bulb with the flat surface flush with the metal receptacle in the reverse procedure.

All lights of this type must have a "starter" (B) in order to actuate the light.

The function of the "starter" is to actuate a filament in the bulb which ionizes the gas, and as soon as the gas is ionized, the starter unit and filament automatically shut off.

If the light fails to actuate, malfunctioning of either the bulb or starter may be the source of trouble, in which case both must be individually tested. In case it is necessary to replace the starter unit, completely dismantle the lamp down to the base and disconnect the wiring by removing plug (C). The starter unit may now be removed with a blunt instrument by pushing it out of the base. When installing a new unit, it may be necessary to lift up slightly on the prongs (E) to engage in slots (F) to make contact. Reconnect wiring and test for proper actuation of the light.

The amount of light is governed by a shutter control (G) located on the top of each lamp. By rotating this unit, the amount of the intensity of the light can be controlled.

There is also another control for daylight or ultra-violet light and this is accomplished by moving or rotating the case (D). Ultra violet lighting is accomplished by a violet screen (H), built into the case, while the daylight effect is obtained through

slot (I). CAUTION: When dismantling or reassembling the lamp, be careful not to damage the shutters or the case. The shutter is made of bakelite and will break easily.

The recorder light uses two 25 Volt .2 Amp. single contact bulbs. These bulbs are in series and obtain power from the 32 Volt terminals (marked A and G) on the recorder Teletorque motor (Figure 39). Since these bulbs are in series, one bulb will not light if the other is burned out. Any break in the circuit will shut off both lights. The recorder light assembly is held in place by a friction spring and will slide up or down, to suit the convenience of the instructor.

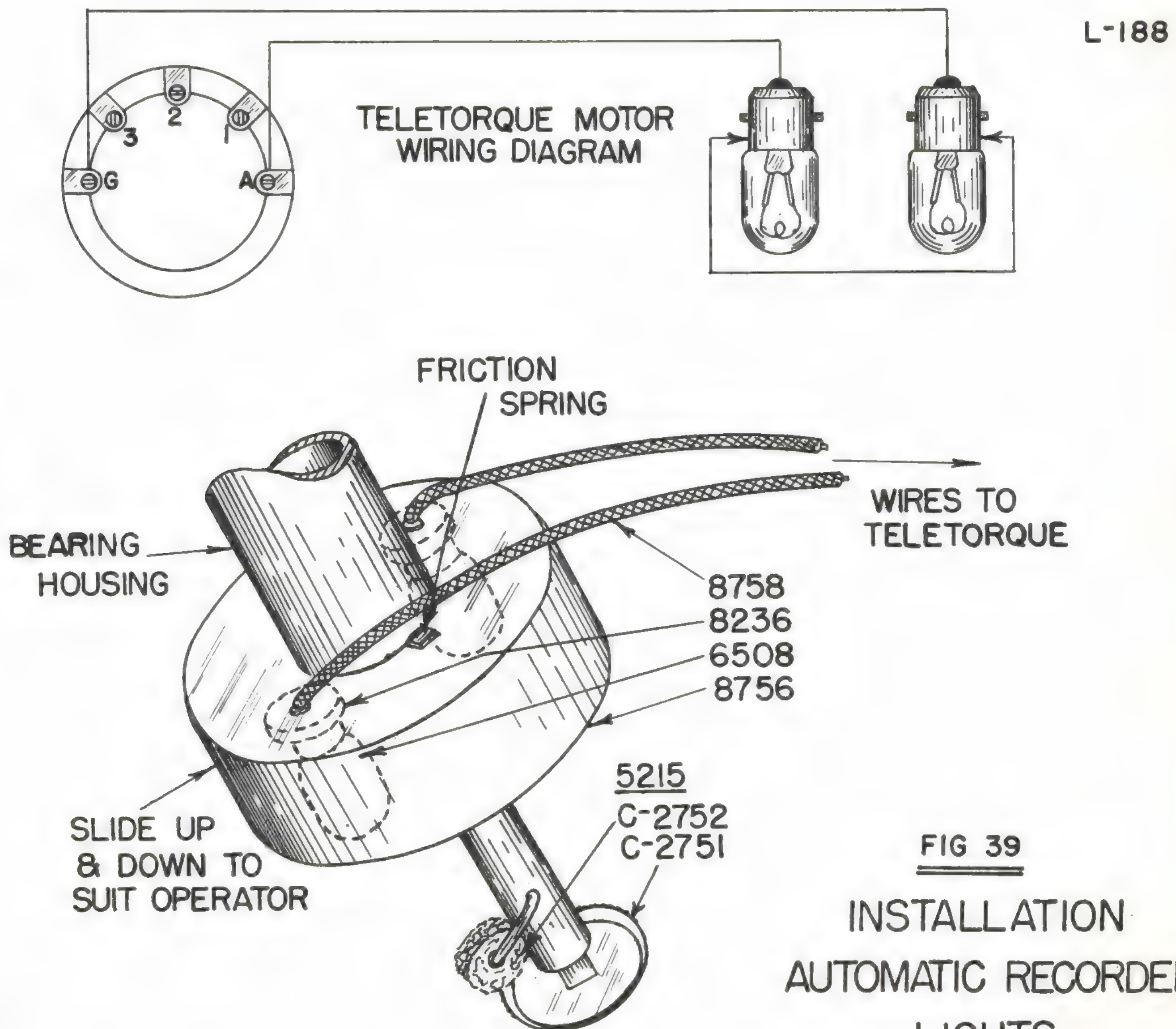


FIG 39

INSTALLATION
AUTOMATIC RECORDER
LIGHTS

SECTION XI

FAN - ROUGH AIR AND VIBRATOR MOTORS

An electric fan is provided in the nose of the Trainer to ventilate the cockpit. This fan is a standard unit requiring only occasional oiling and the care ordinarily given such a unit.

Rough Air Motor

This is a small unit located under the seat, the only purpose of which is to drive the rough air generator. Current supply to this motor is controlled by the Trainer main switch; therefore, this motor is always in operation when the Trainer is running. The necessary reduction gears are built into the frame work of this motor so that it is removable as a unit for inspection or repair. It should be lubricated weekly.

Vibrator Motors

Three other small motors are provided similar to the one mentioned above. These motors are located as follows: One on the instrument panel in the cockpit, one on the instrument panel behind the cockpit in the tail of fuselage, and one in the remote instrument cabinet on the instructor's desk. These motors are made to provide vibration merely by mounting a small adjustable unbalanced fly wheel on each motor shaft. The unbalanced fly wheels are secured to the vibrator motor shaft by set screws. Each motor has two such fly wheels. (See Figure 47) By loosening the set screw in one fly wheel and rotating it a few degrees relative to the other fly wheel, the degree of vibration may be adjusted to the desired amount. WARNING: Too much vibration is a source for erratic instrument indications.

SECTION XII

ICE VALVE AND DE-ICER EQUIPMENT

The ice valve and neon lamp assembly are suspended from the right rear longeron and are part of the icing and de-icing equipment.

Icing of the airspeed is accomplished by "freezing" the airspeed indication by closing the icing valve, which shuts off vacuum to the airspeed indicator. This causes the airspeed to remain stationary, regardless of throttle setting and changes of attitude.

As soon as the student notices the malfunctioning of the airspeed indicator, he should throw a switch located on the instrument panel C which is labeled pitot tube heater. The function of this switch is to light the neon lamp located next to the icing valve and thus to inform the instructor that the student is aware of the ice and has turned on the pitot heater. See Figure 40.

L-178

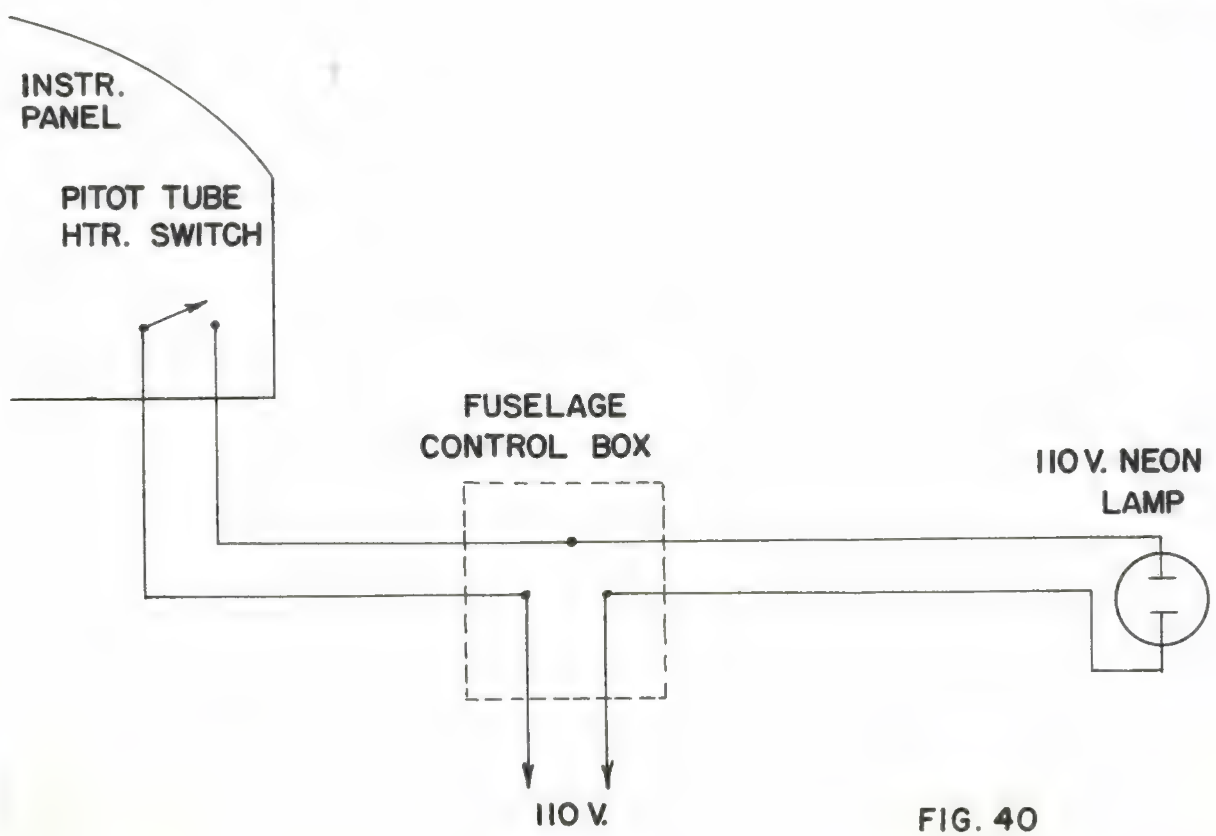


FIG. 40

CHAPTER V

DAILY AND WEEKLY INSPECTION AND MAINTENANCE

SECTION I

DAILY INSPECTION AND FLIGHT CHECK

The Instructor should assure himself daily that his Trainer is functioning perfectly. He will then be able to answer confidently when some student tries to lay blame on the instruments instead of on himself. Also, the best results cannot be obtained with poorly maintained equipment. The following Daily Check and Flight Test require only a few minutes effort and should be done religiously.

Daily Inspection

1. Clean the bleed holes, using a tool or material that will not enlarge the hole.

2. With Trainer floating in the locks (see Chapter 6 Section 2 Item 3) and throttle fully open, check for proper vertical speed.

3. With Trainer still floating in the locks, and throttle set at cruising (Climb-Dive Valves closed), see that the airspeed and R.P.M. are correct (see Figure 43).

4. Check airspeed and tachometer, throttle closed.

5. Check Turn Indicator for a rate of 180 degrees in one minute.

6. Check that Compass Deflector functions at a rate of turn of 1½ degrees per second.

7. Check deviation card if any doubt of its accuracy exists.

8. Check neutral position of controls.

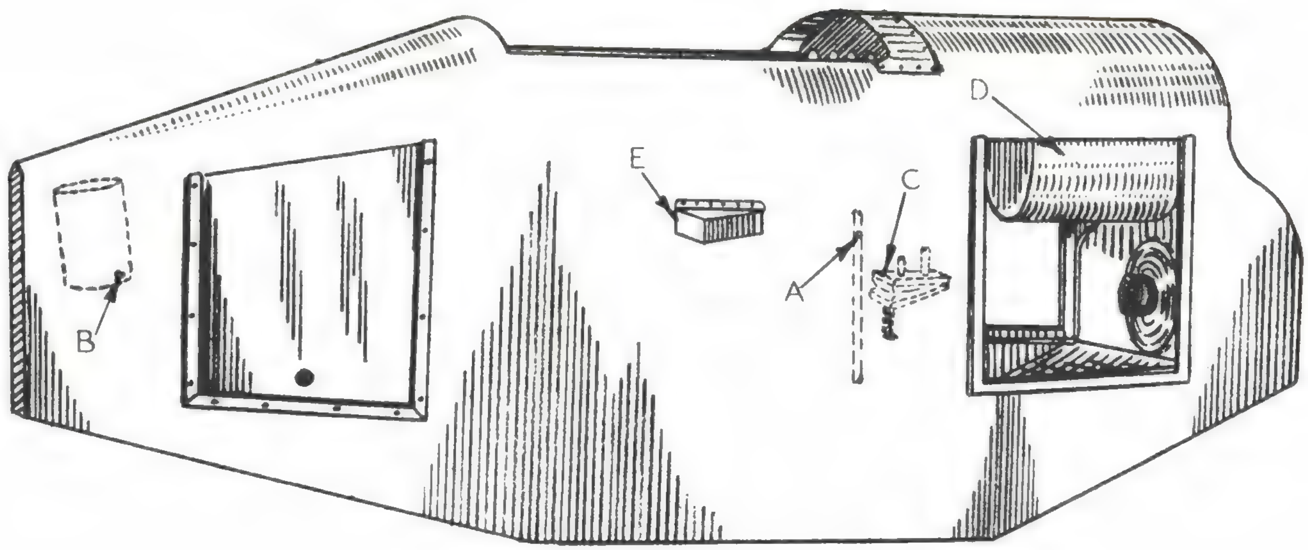
9. Clean Trainer inside and out.

Daily Flight Test.

The Instructor can easily turn himself loose in the Trainer by the following steps; standing outside the Trainer, turn on the main

LOCATION OF BLEED HOLES & TURN INDICATOR REG. BELLOWS

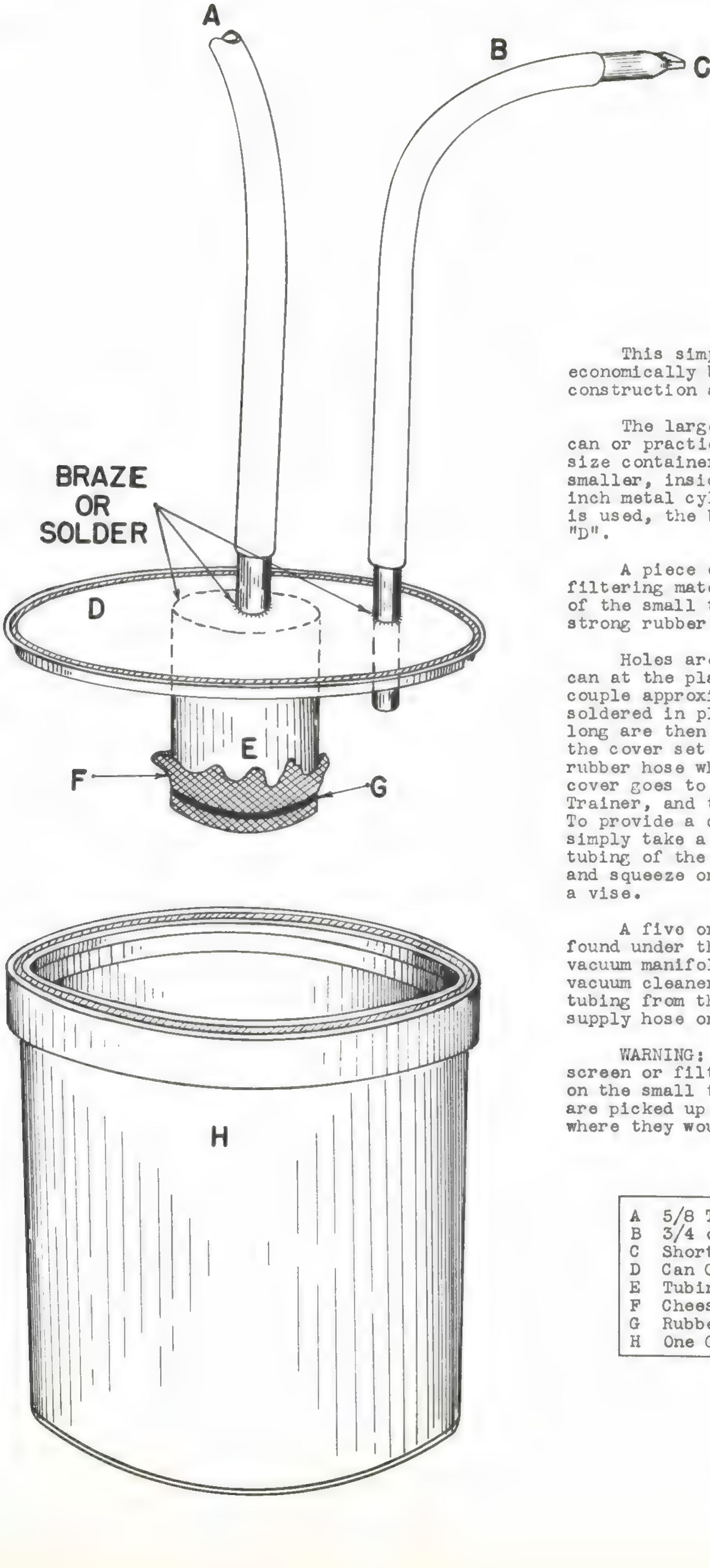
FIG. 41



A - TACH. BLEED HOLE
B - AIRSPEED BLEED HOLE (AIRSPEED DAMPENING TANK)
C - TURN INDICATOR REG. BELLOWS
D - CLIMB DIVE TANK
E - PEEP HOLE

MARCH 1, 1942

Link Trainer Vacuum Cleaner



This simple device can be built readily and economically by any Trainer maintenance man and its construction and use is recommended.

The large tank "H" may be a discarded paint can or practically any other approximately one-gallon size container with a tight fitting cover. The smaller, inside one, "E" is merely a four or five inch metal cylinder of almost any kind. If a can is used, the bottom is soldered to the large cover "D".

A piece of cheesecloth, wire screen or other filtering material is then placed over the open end of the small tank at "F" and held in place by a strong rubber band or other secure method.

Holes are then made in the cover of the large can at the places indicated on the sketch and a couple approximately 3 inch by 5/8 inch nipples soldered in place. Rubber hoses four or five feet long are then slipped over both these nipples and the cover set in place on the large can. The rubber hose which comes from the middle of the cover goes to any convenient vacuum supply in the Trainer, and the other hose is used as a pick-up. To provide a convenient nozzle for the pick-up hose, simply take a three or four inch piece of metal tubing of the correct size to slip into the hose and squeeze one end of it partially closed in a vise.

A five or six inch length of hose will be found under the seat of the Trainer connecting the vacuum manifold to the aileron valve. To use the vacuum cleaner simply remove one end of this short tubing from the manifold and slip the vacuum cleaner supply hose on in its place.

WARNING: Do not use this device without the screen or filtering material held properly in place on the small tank, otherwise metal objects which are picked up would be transmitted to the turbine where they would do extreme damage.

A	5/8 Tubing to Suction Supply in Trainer.
B	3/4 or 7/8 Rubber Tubing to Nozzle.
C	Short Piece Steel Tubing-One End Squeezed.
D	Can Cover.
E	Tubing or Small Can.
F	Cheese Cloth or Filtering Material.
G	Rubber Band to Hold Filter
H	One Gallon Can.

switch. Reach up under the seat and flick over the spin valve, to stop the tendency to turn or "spin". Still standing outside, release the rear locking strap. Climb into the Trainer and then release the side strap.

1. Note general functioning of all instruments.

2. Check that lag and smoothness of airspeed indicator is normal.

3. Check that normal vertical speed can be maintained during climbing at cruising speed, and descending at gliding speed.

4. Check turning "coast" (slippage of belt).

5. Check that with the Trainer level the ball bank indicator is centered and the horizon bar level.

6. Check that the Trainer will return to a level position from a fully banked and fully nosed up or down position.

SECTION II

WEEKLY INSPECTION

The Trainer should be thoroughly inspected and serviced at least once every 50 hours of operation, or once each week. This should be strictly adhered to. Since this cannot be done in a few minutes, it is recommended that one half day per week be set aside for this work.

1. Repeat daily inspection.

2. Remove the cover of turning motor.

   a. Lubricate the sliding valves with powdered graphite applied with a damp rag. Do not use oil or grease on these valves.

   b. Inspect and test bellows for leaks. (Patch leaks with material furnished for this purpose by the factory).

   c. Check ball bearings for free turning.

   d. Clean belt pulleys with cloth and gasoline.

   e. Check all set screws on gears, also leather or composition nuts on slide valves.

   f. Test for smooth turning at a standard rate turn.

3. Check pitching and banking bellows for leaks.

4. Lift up slightly the top half of the three main valves under the pilot's seat. Lubricate them with three or four drops of a good grade of gun oil. (See Lubrication Chart). Check for free turning.

5. Check ventilating fan, rough air and vibrator motors, and lubricate if necessary. Also check driving gears on the rough air motor for looseness and for proper mesh with the rough air gears.

6. Clean collector rings and inspect brushes.

7. Clean turbine motor commutator and check brushes. (See Chapter 6 Section 6).

8. Check bellows ball (#1516 Figure 3) and sockets in floor of fuselage and lubricate with one drop of heavy oil.

9. Check compass for correct headings with the cards on the octagon and with deviation card.

10. "Flight check" the Trainer to be sure that all controls are equalized in both directions.

11. Clean Trainer. It is recommended that the Trainer be waxed as this assists greatly in keeping it clean.

12. Check all rubber tubing for chafing, cracking, or buckling.

13. Clean bleed holes in airspeed dampening tank and tachometer tubing (see Figure 41).

14. Check cruising speed:

    a. airspeed.

    b. tachometer.

15. Check rate of climb:

    a. Locked level full throttle.

    b. Maximum, (Nosed up) full throttle.

16. Check action of Spin Trip Assembly.

17. Make leak test.

18. General, careful inspection of wires and tubings in an effort to discover anything that might cause trouble during the next week. Check that all nuts and screws are tight.

19. Check rate of turn at which compass deflects.

20. Clean Turn Indicator inlet nozzle.

21. Check Turn Indicator for correct rate of turn.

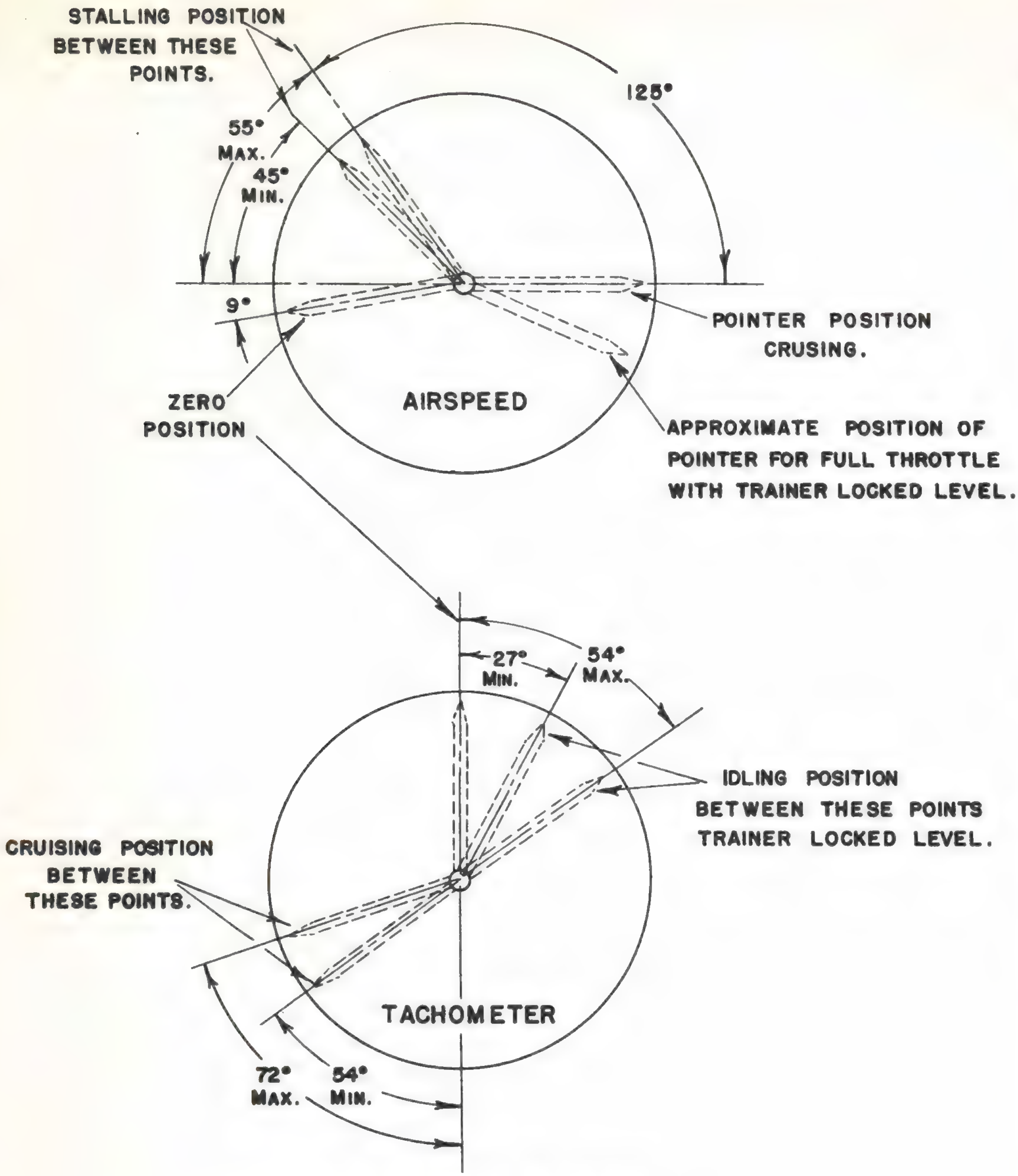
22. Clean, replace Dir. Gyro, air filter.

23. For details of any needed adjustment, see Chapter 5.

24. Thoroughly clean inside of Trainer and Radio compartment in desk with Vacuum cleaner (see Figure 42).

25. Clean and polish entire Trainer.

WARNING: Be particularly careful to keep all bellows and hose free from oil and to avoid over-lubrication on other parts.



POSITION OF POINTERS ON AIRSPEED
AND TACHOMETER
FOR VARIOUS THROTTLE SETTINGS

FIG. 43

SECTION III

PERFORMANCE DATA

AIRSPEED AND TACHOMETER:

See Figure 43, Chapter 5, Section II.

VERTICAL SPEED:

Locked Level, Throttle fully open - Approximately 600 feet per minute.

Nosed up, throttle fully open, maximum climb at 1000 feet altitude - Approximately 1300 feet per minute.

At gliding speed (3/4 of cruising speed), minimum rate of descent, throttle closed, at 1000 feet altitude - 500 feet per minute.

STALLING SPEED:

May be set to stall anywhere between 65 M.P.H. and 80 M.P.H. according to preference. Stalling speed must be the same whether nosed up with throttle closed, cruising, or throttle fully open.

COMPASS DEFLECTOR:

Deflects at a rate of turn of 1-1/2 degress per second.

TURN INDICATOR:

At either one needle width or two needle widths, or Rate 1, the Trainer should turn 180 degrees in one minute.

CHAPTER VI

REGULATING, ADJUSTING, TESTING

SECTION I

TRAINER GENERAL

1. General Inspection

The Link Trainer is somewhat complicated and many of the adjustments depend on previous adjustments. Therefore, it cannot be over emphasized that the Maintenance man must not attempt any repair unless he is very sure of his ground. One wrong move may upset several other adjustments, thus making it appear that the whole Trainer needs resetting when it is necessary to make only one proper correction.

Bear in mind that the Trainer has been properly adjusted at the factory. If it appears to be out of adjustment when received, it is undoubtedly due to some part becoming loose, or the change of altitude where the Trainer is to be installed or the change of barometric pressure may have affected it slightly.

NOTE: Before making any adjustments, make sure that

(1). PROPER ELECTRICAL CURRENT, (CYCLES AND VOLTS), IS UTILIZED.

(2). ALL PARTS ARE SCREWED TIGHT TO THE FUSELAGE.

(3). ALL SET SCREWS ARE TIGHT.

(4). NO EXCESS LOST MOTION EXISTS IN ANY OF THE LEVERS AND RODS.

(5). NO RODS, LEVERS OR SHAFTS BIND IN THEIR BEARINGS.

(6). NO TUBES ARE OFF OR LEAKS DEVELOPED IN THE CONNECTIONS. IF THE TRAINER IS OLD OR HAS BEEN SUBJECTED TO EXCESS DRY HEAT, CHECK THE SMALL RUBBER TUBES FOR SLIGHT CRACKS WHICH MIGHT CAUSE LEAKS.

2. Level Trainer

See Chapter I, Section III.

3. Main Bellows

These Bellows should be inspected for leaks, with special atten-

tion to corners and creases and to the overlapped splice in the fabric. Due to climatic or humidity conditions, these seams may become unglued and leak. Such openings should be re-glued, and any other leaks patched immediately.

An escape valve is provided in the top of each bellows. This consists of a row of holes through the top plate, covered by a strip of bellows fabric. This strip must lie flat (edges not curled) to avoid leakage. If the strip does not fit properly, it should be replaced by tacking on a new piece of fabric in the same manner as the old one.

All hoses leading to the main bellows (also turning motor hoses) should be inspected to see that they are not loose, kinked or chafed through.

4. Patching Directions

It is recommended that only the patching cement supplied by Link Aviation Devices be used on the Trainer. Most other cements dry too hard, become brittle, and crack or let go in a short time.

In general, the patch should be of a material a grade lighter than the fabric being patched, to avoid undue stiffness.

Both surfaces must be clean and dry. Each surface should be given a coating of cement and allowed to stand at least 20 minutes, preferably overnight. A second coat should then be applied to each surface and the patch pressed down smooth. The Trainer may then be turned on immediately - the vacuum will help hold the patch in place while it is drying.

5. Rough Air

The Rough Air System should be inspected to insure that none of the hoses (3/8" rubber tubing) are off or leaking. Check that the flap valves open 3/16 of an inch. NOTE: The two right hand valve flaps should remain open, and the other four closed, when the Rough Air is cranked to the "off" position.

6. Turning Motor

The Turning Motor should be visually inspected for the following points.

(1). Both hoses connected.
(2). No holes in bellows.
(3). No loose or missing patches on bellows.
(4). No slide valve springs missing.
(5). No leather or composition nuts missing.

(6). Valves all in place and working properly.
(7). Valve seats well graphited (no bare wood showing).
(8). Connecting rods not binding.
(9). Crankshaft pinion gears tight on shaft.

If wear occurs in the connecting rods, remove the screw and thin washer. Washers of the proper thickness can be made of standard brass shim stock. CAUTION: Make sure there is absolutely no bind, as even a slight amount will cause uneven running of the motor. It is better to have the rods too loose than too tight. If squeaking occurs on the bearing of these rods, a single drop of oil may be applied.

Lubrication of the valves is assomplished by unscrewing the leather nut where the valve rod hooks to the connecting rod, unhooking the coil spring and removing the valve. Dip a damp rag into powdered graphite. Rub the graphite well into the wood on the face of the valve. Fasten a rag to a stick and repeat this operation to lubricate the sliding valve seats. Do not use oil on these valves. Graphite every fifty hours of operation, or oftener if squeaking, or if wood shows through the graphite. Do not lubricate other parts with too much oil or grease as there is danger of oil being thrown on the slide valves.

Timing of the opening of the slide valves is done with the two leather or composition nuts which position the slide valve yoke or the valve rod. The valve should start to open, and the bellows fabric start to move just as the connecting rod passes dead center. This adjustment should not be disturbed while graphiting valves.

The gears should be greased lightly every 100 hours. Ball bearings are of the sealed type and do not require lubrication. Do not let any oil get on the bellows. (See Lubrication Chart).

Belt Tightener.

The belt tightener (Figure 17) should be tightened just tight enough so that the motor will turn the Trainer promptly. The belt should be loose enough so that there is some slip or coast when opposite rudder is applied to change a turn from one direction to the other. It should be tight enough so that the Trainer will start a turn from a still position with proper response.

7. Adjusting Main Valves to Neutral

With the Trainer running and maintaining a level flight position (locks disengaged), the wheel (or stick) and rudder pedals should be in a neutral position. If the controls are not neutral, proceed as follows:

Rudder Valve

Set the rudder pedals even with each other and turn on the Trainer. With the Trainer locked in both side and rear straps, turn on the rough air. Set directional gyro to zero and uncage; Trainer should yaw an equal amount in both directions, if not, rudder valve is off center. The rudder valve is located under the right rear corner of the seat and the socket extends down through the fuselage floor. This socket and the Allen set screw are reached from outside the Trainer, under the cloth skirt. Be sure the Spin-trip is in normal flight position, then loosen the set screw and rotate the bottom half of the rudder valve one way or the other until the Trainer yaws an equal amount in both directions. Tighten set screw and recheck that the yaw is equal and the rudder pedals are even with each other.

Center Leaf of Aileron Valve (Automatic Bank with Turn Type)

First make sure that the Spin Trip Assembly is in its normal operating position and that Rudder Pedals are in line with each other straight across the fuselage. Leave the Trainer turned off. Note the two large elbows which extend out of the bottom of the Aileron Valve. These elbows should be on a line level with the fuselage floor. Lock the base (fixed portion) of the valve in this position by means of the lock screw in the bracket.

The next step is to position the center leaf. The desired position of this leaf is with its stop midway between the two dowel pins located in the fixed part (base) of the valve. (See Figure 19.3). To get the center leaf in this position, adjustment must be made on the link rod ("D") attached to the center leaf on one end and to the bell crank ("E") on the other end. If sufficient adjustment cannot be obtained on this rod, an additional amount may be obtained from the ball joint on the rod ("F") leading from the bell crank just referred to, to the Rudder Valve walking beam. After adjusting the fixed portion ("A") of this valve and its middle leaf ("C") to the desired position, proceed with the final adjustment as follows:

Turn on the Trainer, leaving the side and rear locks engaged. Make sure that the Spin Trip Mechanism has returned to its normal position and that rudder pedals are in a straight line across the fuselage. Then loosen the lock screw in the Lever Arm ("G") located on the rear end of the torque shaft, which connects by means of a short link rod ("H") to the front half ("B") of the Aileron Valve. Put the stick or wheel in its neutral position. Then with the Trainer still running, adjust the position of the Aileron Valve Lever Arm ("G") and with it the movable part of the valve, to a position where the Trainer is floating in the side lock. When this condition is obtained, tighten the lock screw in the Aileron Valve Lever Arm. Recheck the control column and Rudder Pedals to make sure they are still in neutral.

Aileron Valve (Interchangeable Stick-Wheel Control)

Turn on the Trainer and center the wheel with neutral spring action and loosen lever arm on the end of the long torque shaft. (NOTE: Rudder valve and center leaf of aileron valve must be centered first.) Move the lever arm right and left without turning long shaft, until the Trainer remains level and floats in the side strap. Recheck stick or wheel for center and secure lever arm to shaft. Recheck Trainer for level and "floating" in side strap.

Elevator Valve (Stick-Wheel Control Unit)

This assembly is similar in adjustment to the ordinary stick control type, except due to the variable spring loading unit, it is necessary to insure that the stick or wheel column is in a vertical position before attempting to adjust the elevator valve to neutral. Should it be necessary to change the position of the stick or wheel forward or back to obtain the vertical position, it is accomplished by loosening the bottom spring lock nut and increasing bottom front spring tension to move the stick or column back, or decreasing spring tension to move it forward. Tighten lock nut and proceed to adjust lower half of the elevator valve so the Trainer will remain level and "float" in the rear strap. Excess play in this linkage is removed by adjusting ball nuts on the spring assembly.

Slipstream Simulators

These units should be checked for any lost motion in the link rods to the controls; for the degree of stiffness; and for leakage.

The stiffness is controlled by means of the "resistance adjustment" shown in Figure 21. This figure also shows the packing nut. If this nut is too tight, it will cause excessive friction and a slight jerkiness at the start of movements.

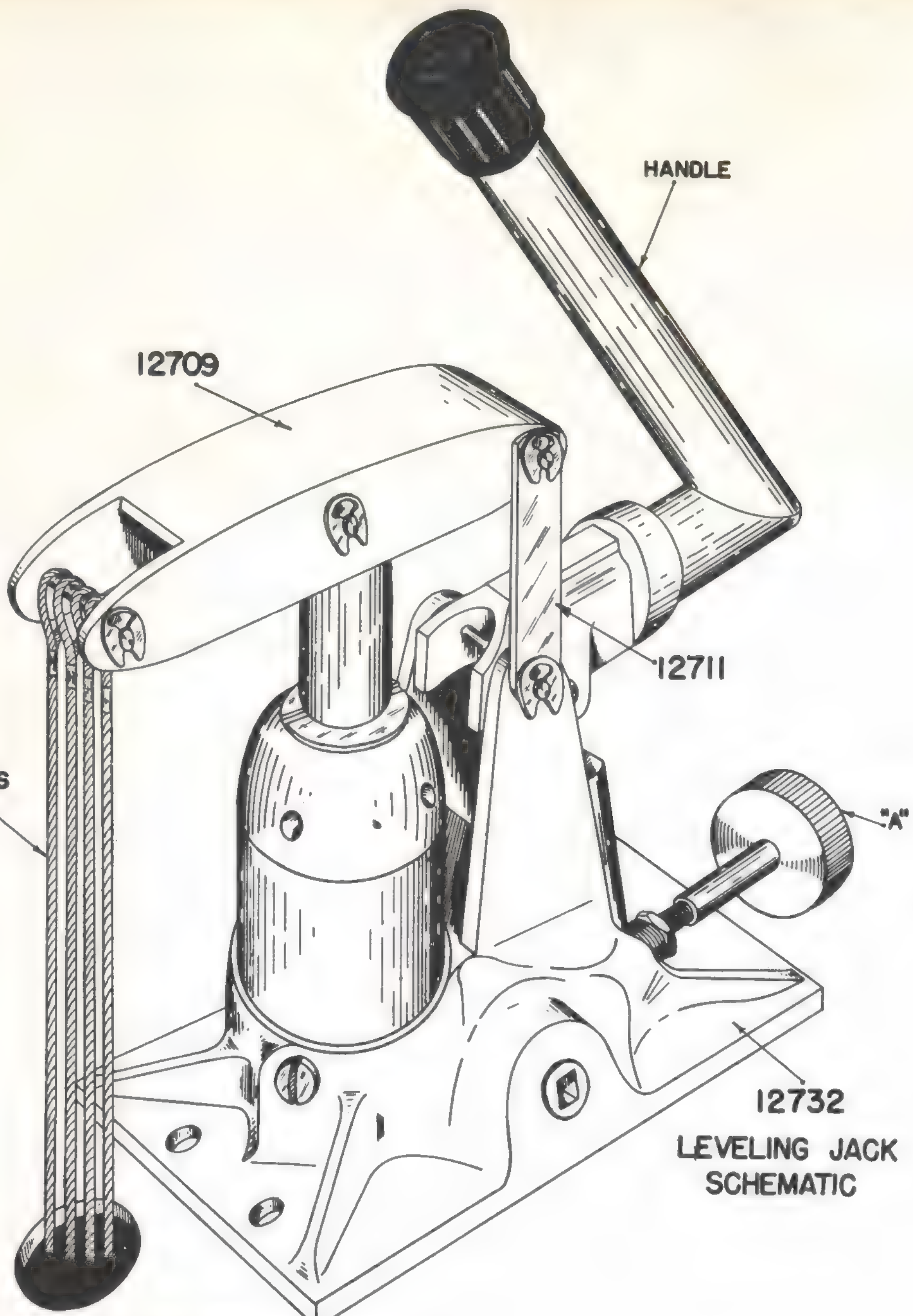
It is seldom necessary to refill the unit. If fluid is required, it should be filled to the bottom of the filler hole. Use only #500 Shock Absorber Oil obtainable from the Link factory.

Automatic Spin

The Spin Trip mechanism should be checked for proper functioning. To do this, turn on the Trainer but leave the fuselage locks on.

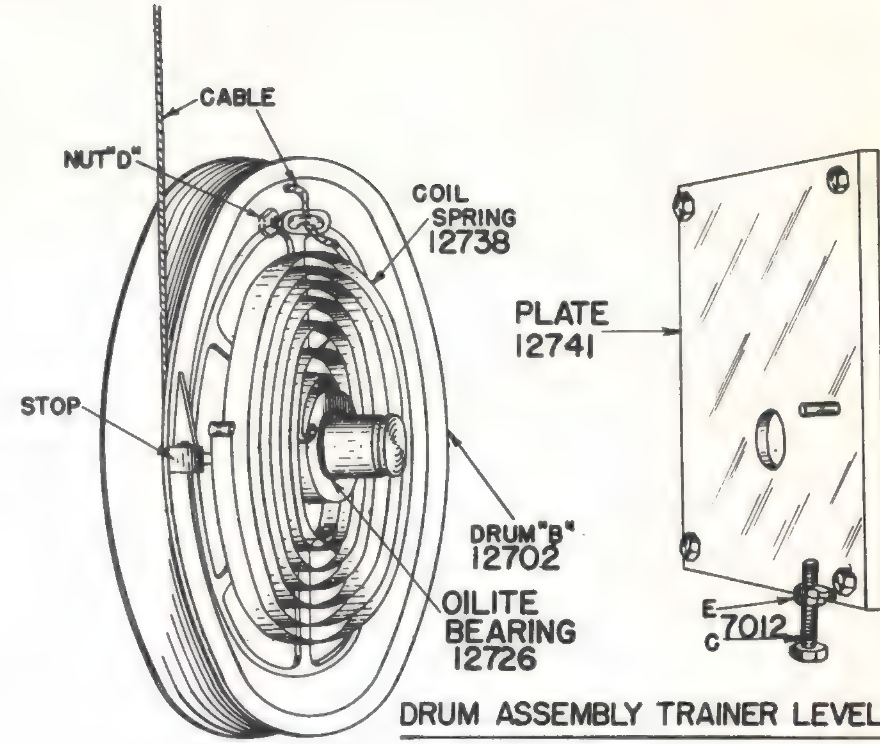
Open the throttle to cruising speed, then flip the Spin Valve pendulum over ("P", Figure 13). The Spin Trip assembly should now return to its normal flight position. To check its action, slowly push the Stall Valve Pendulum ("P2", Figure 8) toward the rear. The Spin Trip should now release and rotate its full travel and all of this movement should be transmitted to the rudder valve. (See Chapter II, Section VI for complete description of the Spin Trip Assembly.)

Release the Stall Valve pendulum, permitting it to go forward, then flip the Spin Valve pendulum over again and the Spin mechanism should again return to its normal locked position.



LEVELING JACK SCHEMATIC

4 CABLES
1-RIGHT FRONT - 12746
2-LEFT FRONT - 12747
3-LEFT REAR - 12748
4-RIGHT REAR - 12749



DRUM ASSEMBLY TRAINER LEVELING

FIG. 45.1

AUG. 1, 1941

LEVELING DEVICE
ADJUSTMENT

The only adjustment which might be required (and this is very seldom) is the tension of the cables. If, after the Trainer has been used for some time, there should be too much slack in the cables so that the fuselage is excessively wabbly while students are climbing in or out, a little slack should be taken out of the cables.

Attach side straps to lock pins on fuselage and open partially the valve ("A", Figure 45.1) on bottom of hydraulic jack and allow cables to become slack. The cable that was slack can now be tightened a bit by loosening nut "D" and pulling cable through a bit. Tighten nut "D". Close valve "A" and jack up until cables are tight. Lock pins on fuselage should be even with holes on lock straps when they are swung up in place. If the lock pins are not even with the lock straps, loosen nut "E" one or two turns. Ordinarily this should be done equally on all four drums. When this last adjustment is being made to cables, it is HIGHLY IMPORTANT THAT THE HYDRAULIC JACK BE PUMPED ALL OF THE WAY TO ITS TOP POSITION. Otherwise the cables may be shortened too much and cause damage later when the jack is pumped to the top.

LUBRICATION

Ordinarily no lubrication should be required other than perhaps a slight film of oil on the cables every month or so to prevent rust. The small pulleys and the large drums operate on oilite (oil impregnated) bearings. The jack itself has a built in reservoir which in normal operation it should seldom, if ever, be necessary to fill. If through the development of a leak, or from having been tampered with, the fluid should be lost, it should be replaced with a good grade of light oil of about S.A.E. No. 20. In order to completely eliminate air bubbles from the jack, this filling operation, when and if necessary, must be done with the jack completely submerged in a container of oil. This should be done with the plunger withdrawn within the jack (in its down position).

SECTION II

INSTRUMENT CONTROL ADJUSTMENTS

1. Leak Test

The Climb-Dive System consists of the Climb-Dive or "Altitude" Tank, Climb-Dive Valves, Altimeter and Vertical Speed Indicator, and their connecting tubing. Leakage in this system would make it difficult, and if the leak were bad render it impossible to obtain correct adjustment of the Trainer. Therefore, before final adjustments are attempted, the "leak test" should be performed. This is accomplished by climbing the Trainer up to one thousand feet altitude, then with Trainer locked in level position, set throttle at cruising position making sure the Climb-Dive Valves, "B" in Figure 8, are closed, (arms against the stops). Tie or wire Stall Valve Arm in closed position (towards the front). Now switch off the turbine or pull the turbine plug, leaving the Trainer main switch "on". This is so the vibrator will be running, giving more sensitive altimeter indications.

If the air system is tight, the altimeter should not lose over 100 feet in five minutes.

If more than 100 feet is lost in five minutes, the source of the leak must be discovered. All tubing connections should be checked for tightness; also, the Altimeter and Vertical Speed Indicator. If the leak is still present after all tubing and connections have been checked, the Climb-Dive Valves should be tested. Disconnect from the valves the tubes leading to the Climb-Dive tank. With the Valves closed (arms against stops) and the Vacuum Turbine running, connect a vacuum gauge of any kind to one valve and then to the other. If the pointer, or column of mercury, of the vacuum gauge moves quickly to approximately 4½ Hg, the valve is leaking badly and must be replaced or readjusted. If the vacuum gauge moves very slowly, the leak is of no consequence. WARNING: The Climb and Dive Valve assembly is adjusted at the factory by special instruments and readjustment should not be attempted without proper equipment and instructions. (This also applies to the Stall Valve, "C" in Figure 8. Experience has shown that once adjusted, these valves seldom need adjusting again. If, however, it is definitely proven that the valve leaks, a trained maintenance man should proceed as instruction in Section IV of this Chapter, or the valves should be returned to the factory or to an authorized repair base.

2. Key Adjustments

Certain key, or basis adjustments are used as a starting point

in re-regulating the instrument control linkages and levers.

It is assumed that the Trainer is level, as described in Chapter I, Section III. The next step is to determine that the horizontal arms on the Pitch Action Shaft, ("D" in Figure 8), and on the Spin Trip Assembly, ("B" in Figure 13), are actually horizontal. These should be checked with a small spirit level. If adjustment is required, lengthen or shorten, as necessary, the compensator and push-pull rods which extend downward to the iron cross in the revolving octagon.

Next, check the two Walking Beams, ("R", Figure 13, and "E", in Figure 8) which pivot on the bellcranks of the Pitch Action Shaft and the Spin Trip Assembly shaft. With the rudder pedals neutral, the first one should be vertical; with the throttle set at "cruising" (Climb-Dive Valves both closed), the other walking beam should also be vertical. It is seldom necessary to readjust these preceding key positions.

3. "Locked Level" Position

Many adjustments in the Trainer are based on the Trainer being exactly in a level flight, cruising position and cruising condition. It is important that this condition be understood and accomplished.

To obtain the "Locked Level" Cruising Position, turn on the Trainer, leaving the side and rear locks engaged. Move the elevator control fore and aft until the rear lock pin is centered in the hole in the strap. The Trainer will then be "floating" in the rear lock strap without any aid from the strap. To make sure of this, remove the lock strap for the moment. The fuselage should not change position and the lock should readily slip back into place.

With the Trainer "Floating", "Cruising Condition" is obtained by opening or closing the throttle until the arms of the Climb and Dive valves are both against their stops. (Both valves closed).

WARNING: The following adjustments cannot be accurately made until the above is thoroughly learned and followed.

4. Throttle Adjustment (Vertical Speed, "Locked Level")

Before starting the Trainer to check or adjust anything pertaining to altitude, the altimeter must be set to read approximately 500 feet below zero.

Leave Stall Valve pendulum tied forward as described under the "leak test".

With the Trainer running and "floating" in the lock straps, open the throttle fully. At an indicated altitude of 1000 feet, the Vertical Speed should indicate approximately 600 feet per minute ascent. This setting is obtained by means of lengthening or shortening rod "F", Figure 8. To do this, disconnect one ball joint from its lever arm and screw rod "F" into or out of both ball joints as necessary to obtain approximately 600 feet per minute vertical speed at 1000 feet altitude, Figure 8. With the throttle fully closed, the rear compensating spring (against the climb valve arm) should be almost fully collapsed. Additional adjustment can be obtained by lengthening or shortening the long control arm connecting the lever arm and the pitch action walking beam.

5. Maximum Climb & Descent (Limit Valves)

If the maximum climb were permitted to become too great, the "mush" valve in the Stall Valve assembly would not be capable of letting air into the system fast enough to show the proper "mush" during "stalls". A plain shut-off type valve is provided at the ends of both the climb and dive valves to restrict the flow of air to the desired rate of climb and descent as shown in the Performance Chart. If the maximum vertical speed is not correct, proceed as follows:

Using a screwdriver, shut off both "limit valves", "G" in Figure 8. These valves are located on top of the Climb-Dive valves. Unlock Trainer and with throttle in "wide open" position, nose Trainer up until maximum climbing speed is reached. (Air Speed Indicator hand at a vertical position). Keep Trainer in this position and open the limit valve on top of climb valve (the one without filter). The Altimeter and Vertical Speed should both show an ascent. Adjust the limit valve until, at an altitude of 1000 feet, a rate of climb corresponding to that listed on the Performance Chart is shown. Nose up the Trainer several times to make sure that the correct setting is obtained on this limit valve. Level Trainer off at an altitude of 1000 feet and set the throttle at "cruising". With the throttle set at cruising, the Vertical Speed should return to zero, and the Altimeter should remain constant.

With Trainer level and the Altimeter showing a height of 1000 feet, set the throttle in the closed position and nose the Trainer down to the maximum diving position (against stops). Open limit valve on top of the dive valve. Adjust the valve so that a dive corresponding to readings shown on the Performance Chart are obtained. Climb Trainer up to 1000 feet and try maximum dive several times to make sure that the setting of the limit valve is correct. NOTE: BEFORE ANY DIVE CAN BE SHOWN ON VERTICAL SPEED INDICATOR, THE TRAINER MUST BE FLOWN TO SOME ALTITUDE ABOVE ZERO.

6. Bleed Holes

There are two bleed holes in Trainers using remote indicating instruments. One of these holes is drilled in the 3/16 inch tubing leading to the Tachometer about a foot from the instrument. The other is drilled in the end of the Airspeed Dampening Tank located in the rear of the Trainer fuselage (see Figure 41).

These bleed holes must be kept open at all times. Before flight testing or adjusting the Trainer, they should be cleaned with a broom straw or soft flexible wire. CAUTION: SINCE THE SIZE OF THE HOLES HAS A DEFINITE BEARING ON THE ACTION OF THE AIRSPEED AND TACHOMETER, IT IS IMPORTANT THAT, WHILE THE HOLES BE FULLY OPEN, THEY MUST NOT BE ENLARGED.

7. Adjusting Airspeed and Tachometer

With the Trainer in "Locked Level Cruising Condition", the airspeed indicator hand should be in an exactly horizontal position, pointed toward the right. If the airspeed reading is low, the knurled nut on the airspeed regulating bellows (Figure 8) should be tightened; if the reading is high, it should be loosened.

In making this adjustment, the nut should be moved only a turn or two and then released from the fingers to allow the bellows to function and the airspeed to settle down again. CAUTION: DO NOT SQUEEZE THE REGULATING BELLOWS TOGETHER BY HAND.

The Tachometer is adjusted in the same manner, to the position shown in Figure 43.

Normally, this is the only adjustment required on the airspeed and tachometer, as the tension of the regulator springs is carefully adjusted at the factory.

With the Trainer still "floating" in the locks, (this should be checked frequently), close the throttle and note the airspeed and tachometer. If the pointer of the airspeed drops lower than 10 m.p.h. below "Stalling Position" (see Figure 43) or the tachometer falls back to less than "Idling Position", it indicates the spring is too stiff. (This could not occur with the spring originally supplied on the Trainer, as it would not grow stronger.) If either instrument does not fall back low enough, it indicates a weak spring. The maintenance man should not be too ready to believe the springs are bad, but should carefully recheck all other adjustments.

If it is finally proven that either of the regulating springs has become too weak, a new spring must be fitted, by careful stretching, to the individual Trainer. To do this, proceed as follows:

Put the new spring in place, leaving the adjusting nut well out toward the end of the thread. Next, turn on the Trainer and adjust the elevator control until there is absolutely no pull - up or down - on the rear locking strap. This means that the lock must be floating in the hole in the strap so that the strap may be slipped off and on again without any change in the attitude of the Trainer fuselage. Then open or close the throttle until the climb and dive valves are both closed (arms against the stops).

The regulating spring adjusting nut should now be tightened until the indicator shows exact cruising speed (see Figure 43). Next, close the throttle.

If the indicator falls back below the proper "idling" speed, the spring is too stiff and must be stretched slightly. To do this, remove the spring. Hook one end of the Spring onto a nail held in a vice or driven into any convenient board (see Figure 46). Place a machinists scale or rule under the spring and against the nail. Stretch the spring to a length of about 4½ inches. Replace the spring in the Trainer and adjust the nut until the indicator is at cruising position just as was done before. Then check the indications on the instrument at full throttle, and again at closed throttle, against Figure 43. The lock strap should be rechecked to be sure the Trainer is still "floating" in the lock.

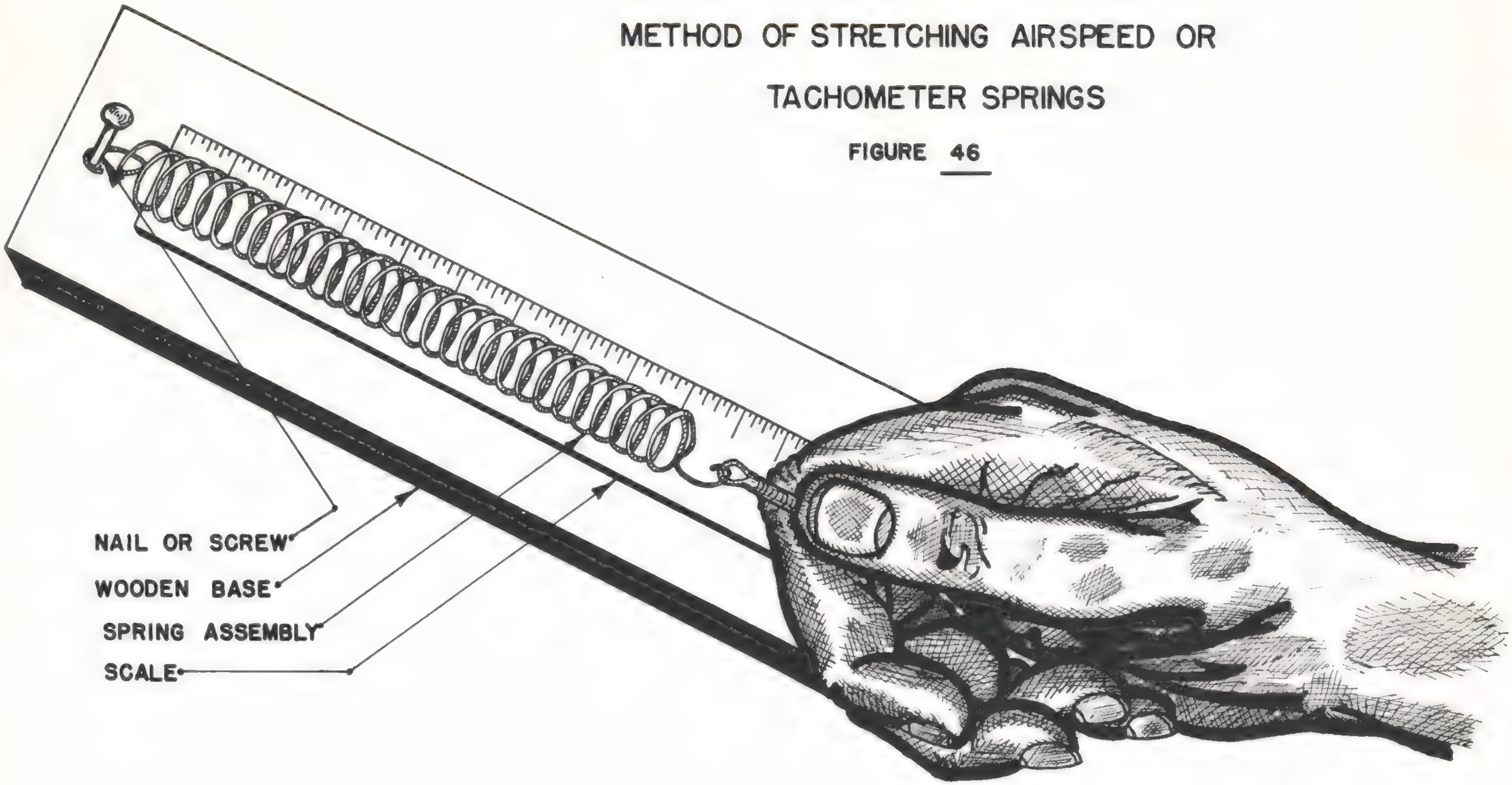
If, with closed throttle, the indicator still falls back too low, the spring must be removed and stretched again. This stretch should be to approximately 4 3/4 inches. Install the spring in the Trainer, adjust and test as above. This process must be repeated until the desired indications are obtained. <u>WARNING</u>: As soon as the indicator shows any effect from stretching the spring (doesn't fall back quite so low) any further stretching must be done very carefully so as not to overstretch and ruin the spring. At this point, the increase in stretch should be only a sixteenth of an inch at a time. If the spring has been stretched too much and is too weak, checks 1 and 2 may check satisfactorily but 3 will not show enough increase from cruising to wide open. Sometimes, if a spring has only been slightly overstretched, a few turns of the coils (not more than 3) can be removed to regain the proper characteristics. However, if it has been overstretched, there is nothing that can be done but replace the spring and start adjustments again.

Airspeed Indicators and Tachometers on the Link Trainer are so designed and calibrated as to require a certain amount of vacuum to move the pointers certain distances around the dial regardless of the

METHOD OF STRETCHING AIRSPEED OR

TACHOMETER SPRINGS

FIGURE 46



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numeral appearing on the face of the instrument. The linkages and regulator are so engineered as to supply just that certain amount of vacuum at any given position of throttle and attitude of Trainer.

In cruising position - namely, with locks on and Climb-Dive Valves closed - for best results the Airspeed Indicator pointers must be horizontal at a position corresponding to the 3 on a clock face, regardless of the numeral appearing under the pointer. If it is desired to simulate a different cruising speed than appears under the pointer as mentioned above, it will be necessary to replace the dial.

Figure 43 shows the proper position for the pointers at stalling speed, cruising, and full throttle speed with locks on.

8. Adjusting Stalling Speed

The Trainer should "stall" and start to spin when the airspeed indicator is in the position shown in Figure 43.

Before attempting to adjust the stalling speed of the Trainer it is well to check the following items. The spring, ("H" in Figure 8), should be three and one quarter inches long (not including end loops) when the bellows on the stall valve is fully collapsed. This measurement can be obtained by the adjusting nut. The pin "I" should be set at approximately 1 19/32 inches from the bottom of the hole in the pendulum arm. These settings are used so the Vertical Speed will indicate the right amount of "mush" and so the Trainer will stall at the same speed with closed, cruising, or open throttle. The stalling speed should be adjusted to agree with the Figure 43. With the Trainer locked level, throttle in cruising position, slide pickup pin, "J", on shaft, "K", until the pickup pin is almost touching pin, "I". Unlock the Trainer and nose it up until the inverted pendulum falls over to the rear stop. At this moment, the position of the Airspeed Indicator hand should be noted. If the position of this hand does not correspond to Figure 43 and is too low, at the moment the Trainer stalls, move the pickup pin, "J", forward slightly and test again. Repeat until the desired stalling speed is reached. Next, adjust the return pickup pin, "L", so it just clears pin "I" on the pendulum arm at the exact moment the pendulum arm strikes the rear stop. (This setting is used so the return pickup pin will not interfere with the stall).

Next, stall the Trainer, by nosing it up, at full throttle, and again at closed throttle. The position of the airspeed hand at stalling should be the same in both cases as it was when nosed up from cruising speed. If spring "H" has not been tampered with, the stalling speed should be the same any throttle position. If this spring has been stretched or damaged, the only remedy is to install a new spring obtained from the factory.

9. Stall Valve Assembly
(See Figure 12)

As the stall valve is properly adjusted and set at the factory it should not require adjustment by a maintenance man until it has been definitely proven that

(a) the valve itself actually leaks, or

(b) the valve has become partially or completely clogged by dust or other foreign matter due to unfavorable operating conditions. As the valve is equipped with an air inlet filter, this very seldom occurs.

The stall valve has two adjustments: (1) a clamping nut "K" to take up any wear or looseness in the threads, and (2) an adjustable stop screw "E" for positioning the pendulum so that the needle just barely touches the valve seat when the valve is in the closed position.

Adjusting for Wear in Threads

If side play can be felt in the valve needle "H", tighten the clamping nut "K" until the pendulum has a tendency to bind; then, back it off just enough to stop the binding.

CAUTION: The pendulum must move freely through its full travel.

Adjusting the Needle

A manometer or vacuum gauge, capable of measuring up to five inches of mercury, will be needed for testing the needle valve for leakage.

If a leak in the stall valve is suspected, proceed as follows:

(a) Disconnect the line which comes from the "altitude" tank at the elbow fitting on the stall valve and attach the vacuum gauge by means of rubber tubing to this fitting.

(b) Remove the air filter from its fitting in the center of the stall valve by giving it an upward pull. Attach one end of a length of 3/16 inch rubber tubing to this fitting, connecting the other end to any source of vacuum in the Trainer.

WARNING: The connection between the valve and the vacuum gauge must be absolutely air tight, as a leak in this connection will give the same kind of indication on the gauge as a leak in the valve. The pendulum should be connected tightly to the base of the needle by means of the set screw "J", otherwise, movement of the pendulum will not affect the position of the needle.

(c) Move the pendulum away from the stop screw "E" until 3-1/2 to 4 inches of vacuum is registered on the gauge.

(d) Move the pendulum back against the stop screw "E" and disconnect the vacuum supply line.

(e) If the gauge reading does not remain constant, i. e., if it shows indications of a leak, loosen the lock nut on the adjustable stop screw "E" and turn the screw counter-clockwise a little at a time, checking the gauge after each adjustment, until no leak is indicated. At this point the needle "H" should be barely touching the valve seat "I", without jamming into it, and the pendulum should be resting against the stop screw "E". Vacuum may have to be applied to the valve several times until an adjustment is reached where the gauge does not indicate a leak.

WARNING: If the adjustable stop screw "E" is turned back too far, the pendulum will jam the needle into the valve seat. If this is done, the valve seat will be damaged and a new one will have to be installed. Although the valve will not leak in the closed position, if the needle has been jammed into the valve seat, it will not give a correct indication of "mush" or stalling speed, as the valve seat will be flanged out.

(f) When the vacuum gauge indicates no leakage and the pendulum rests against the stop screw "E" without jamming the needle into the valve seat "I", tighten the lock nut on the adjustable stop screw.

(g) Recheck the valve for leakage, as the tightening of the lock nut may have changed the position of the adjustable stop screw.

If an adjustment cannot be made so that the gauge indicates no leakage when the pendulum is resting against the adjustable stop screw, the stall valve assembly will have to be removed from the Trainer and dis-assembled.

Dis-assembly of Stall Valve

To dismantle the stall valve for repair or overhaul, proceed as follows:

(a) Remove the stall valve assembly from the Trainer by disconnecting all tubing on the stall valve and stall bellows, unhooking the spring from the bellows and removing the four screws from the base of the stall valve.

(b) Loosen the small machine screw "J" at the base of the pendulum and remove the pendulum.

(c) Remove the clamping nut "K".

(d) Remove the valve needle "H" by turning it clockwise (threads are left handed) and place it in a safe clean place.

(e) Place the base of the valve assembly in a vise and with a suitable wrench remove the right angle pipe fitting from the end of the valve body.

(f) Remove the valve seat clamp screw "L" from the valve body with a small screw driver.

(g) Remove the valve seat "I" by pushing it out of the valve body.

Clean the needle, valve seat and valve body thoroughly. Inspect all parts, especially the valve seat, for wear or damage. Damage or wear to the needle seldom occurs as it is specially hardened. However, if the needle has been jammed into the valve seat, the valve seat will probably be damaged and a new one will have to be installed.

Reassembly of the Stall Valve

To reassemble the stall valve proceed as follows:

(a) Place the valve seat "I" in the valve body with the polished surface and beveled edge towards the pendulum end of the valve. Use a tooth pick or similar instrument to keep the valve seat from turning over when it is pushed into the valve body.

(b) Screw the valve seat clamp screw "L" into the valve body and tighten.

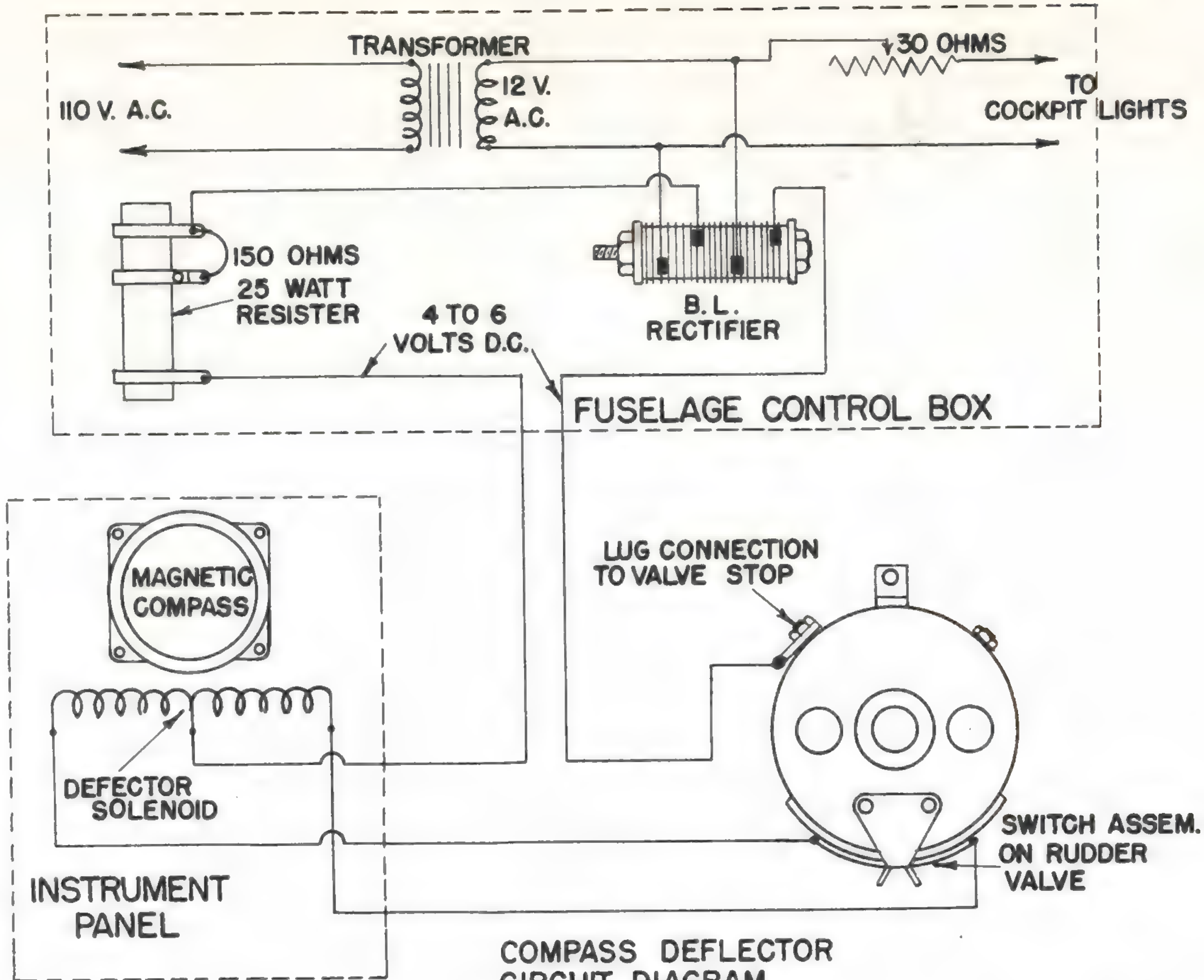
(c) Spread a thin coating of thread lube on the threaded part of the elbow fitting and screw it in place.

(d) Spread a thin coat of oil on the valve needle "H" and start it in the threads.

(e) Screw the needle in slowly, using the fingers, (do not use a screw driver) until it barely touches the valve seat; then, back the needle off one-sixth of a turn.

(f) Install the clamping nut "K" but do not tighten it up.

(g) Adjust the stop screw "E" on the stall valve bracket until there is 3/8 of an inch between the end of the screw and the inside of the bracket edge.



COMPASS DEFLECTOR
CIRCUIT DIAGRAM

FIG. 46.1

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(h) Install the pendulum on the end of the valve needle and, with the pendulum placed against the stop screw "E", tighten the lock screw "J" on the pendulum.

(i) Tighten the clamping nut "K" until the pendulum has a tendency to bind when it is moved back and forth; then, back off the clamping nut until the pendulum moves freely.

(j) Proceed to adjust the stall valve as previously outlined for the remedying of a leak.

(k) Replace the stall valve assembly in the Trainer, being sure to connect all tubing and to hook the spring back on the stall bellows.

If the restriction "N" in the three-way jet assembly "M" becomes clogged with dust or other foreign matter, vacuum will be unable to act on the line to the spin trip bellows and the Trainer will not spin. To remove jet assembly "M" for cleaning, disconnect tubing from fittings "O" and "P" and loosen set screw "R" (Figure 12). Clean jet assembly by inserting a wire less than 25/1000 of an inch in diameter in fitting "P" through restriction "N". The dust or foreign matter thus loosened may be blown out of the jet assembly.

<u>NOTE</u>: If the Trainer has been operating for a long period of time in a smoky or dusty room, the restriction "N" may become so badly clogged that it will be necessary to soak the jet assembly in carbon tetrachloride to remove the accumulation of dust and tar.

10. Turn Indicator

Most American turn indicators are calibrated to show either one needle width deflection, or two needle widths, during a turn at a rate of 3 degrees per second. Reid & Sigrist, and other indicators, usually have their scales divided into Rate 1, Rate 2, etc., indications. The intended rate of turn and the desired deflection must be known before adjustment can be made.

Knowing the desired rate and deflection, turn on the Trainer, leaving the fuselage lock straps engaged. Still standing outside, reach under the seat and flip the spin valve over, to get the Trainer out of its attempted spin. Allow the Trainer to run for several minutes to permit the gyro to reach operating speed.

Then climb into the Trainer, leaving the fuselage locks engaged. Apply rudder until the proper deflection of the Turn Indicator needle is obtained. With a stop watch, note time required for a 180 or 360 degree turn. If the turn is completed too soon, the tension of the

Turn Indicator regulator bellows spring must be increased. If the turn is too slow, the spring tension must be decreased. (See Figure 41 .)

CAUTION: Do not attempt to change a one needle width indicator to two needle widths by merely increasing the vacuum. To do so will ruin the instrument. If this change is desired, the centering spring must be replaced and the instrument recalibrated. This should be done only by a competent instrument man, or the manufacturer.

11. Compass Deflector

If a slow turn is started from a northerly heading, the compass should start to swing when the turn indicator shows one half the deflection of a standard rate (3 degrees per second) turn. (WARNING: The Turn Indicator must have been running long enough to attain normal operating speed.)

If the needle is too far out when the compass starts to swing, the contact plates on the bottom half of the rudder valve (Figure 46.1) must be moved slightly nearer each other. Adjust the right hand plate for left turns, and the left hand plate for right turns. If the compass swings with too little movement of the turn indicator, the plates should be moved apart slightly.

Both contact plates and the moving contact must be kept clean.

The amount of effect on the compass is determined by adjustment of the sliding contact on the resistor located in the fuselage control box. (See Figure 46.1) To check the amount of deflection, head the Trainer North and turn on the main switch. Have someone hold the Trainer from turning and apply enough rudder to deflect the compass. It should deflect approximately 30 degrees. When the left rudder is applied, the compass should swing to a heading of about 30 degrees; when right rudder is applied, it should swing to about 330 degrees. (In the Southern Hemisphere, the swing should be reversed. To accomplish this, simply reverse the wires leading to the two plates on the rudder valve.)

12. Vibration and Positioning of Vibrator Weights

Because instruments cannot be built entirely free of friction, they require a certain amount of vibration to obtain smooth operation. If an instrument lags excessively and then moves unsteadily it indicates that the vibration should be increased by further unbalancing the bibrator flywheel. WARNING: Too much vibration has

been known to cause extremely erratic instrument indications. If this condition is expected, stop the vibrator (by grasping the small flywheel) and note the effect, if any, on the instrument. The correct amount of vibration will move the pointer around the dial smoothly without occasional interruption. This effect may be obtained by starting with a minimum amount of vibration and gradually working up to the desired effect. Vibration is maximum when the two halves of the flywheel are in line with each other, as in "A" (Figure 47), minimum when they are opposite, as in "B", and in position "C" half of normal vibration is achieved. Excessive end play of the flywheel may cause erratic instrument indications. The inner half of the flywheel should be set on the shaft so that the end play in the shaft is seven thousandths (.007) of an inch.

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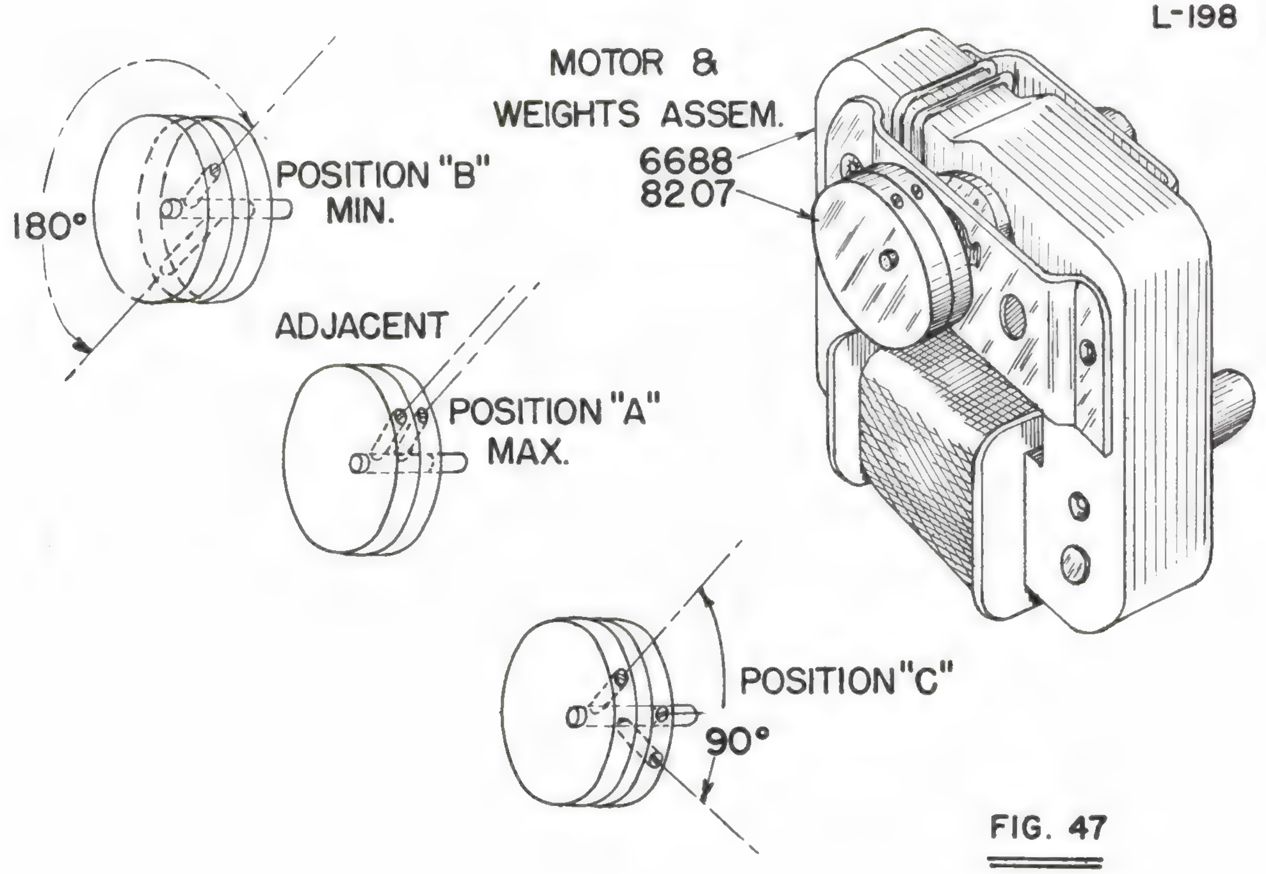
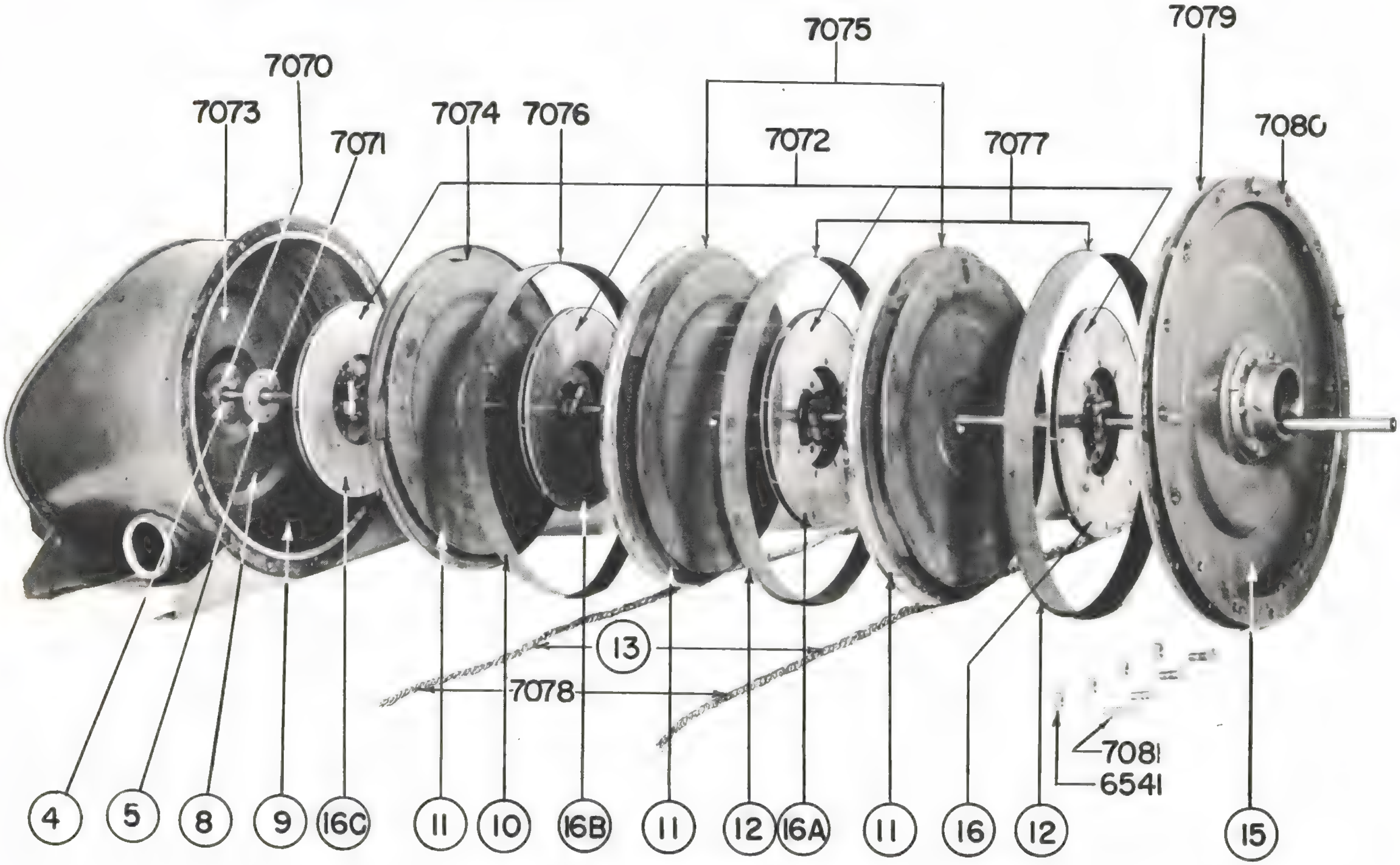


FIG. 47

ASSEMBLY NO. 8590



TURBINE ASSEMBLY

FIG.- 50

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should be used. It should have a melting point of about 275 degrees Fahrenheit, it must be free from separation of oil and soap under operating or storage conditions, free from acids, alkalis or abrasive matter. A small supply of grease which meets the above specifications is furnished with each Trainer. Additional quantities may be obtained from the Link company. We recommend and stock Lubriko M-6 made by the Masters Lubricants Company of Philadelphia.

Lubrication Procedure

MORE TROUBLE HAS BEEN CAUSED IN THIS UNIT BY OVERGREASING THAN BY NOT GREASING ENOUGH.

The bearings should be lubricated every 100 running hours. Be careful not to overdo it, however, as excess grease would be thrown onto the commutator and brushes, and in time cause the brushes to stick in their holders.

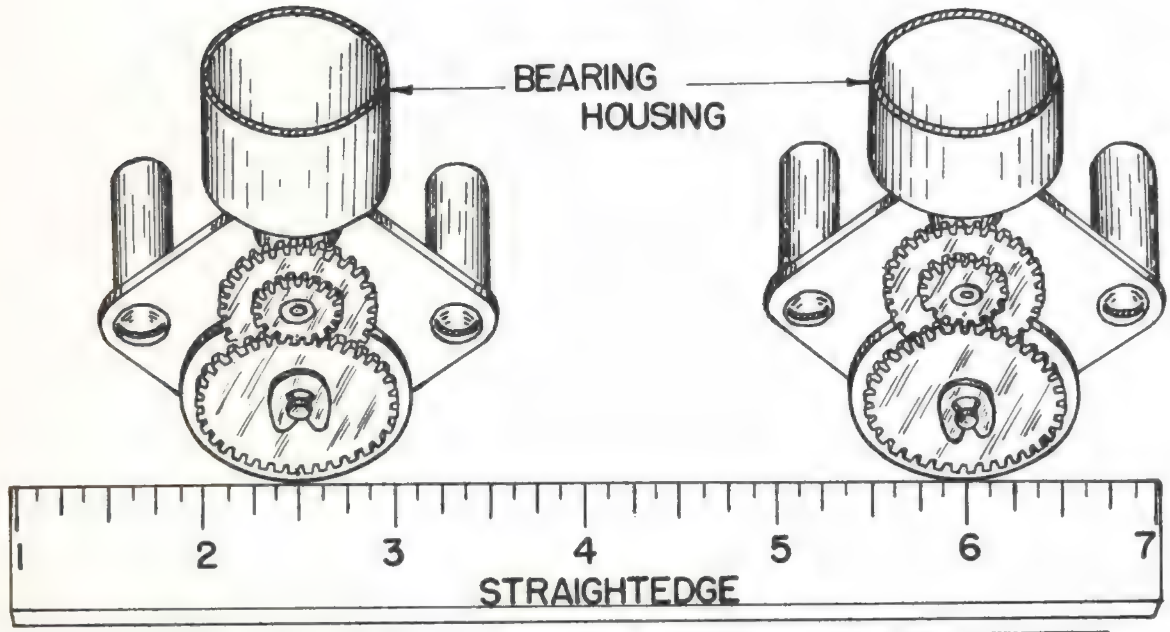
Sticky brushes will result in excessive arcing, overheating of the motor, weakening of brush springs and eventual failure of the motor. To prevent excess lubrication and yet to insure a proper amount, the following procedure is recommended:

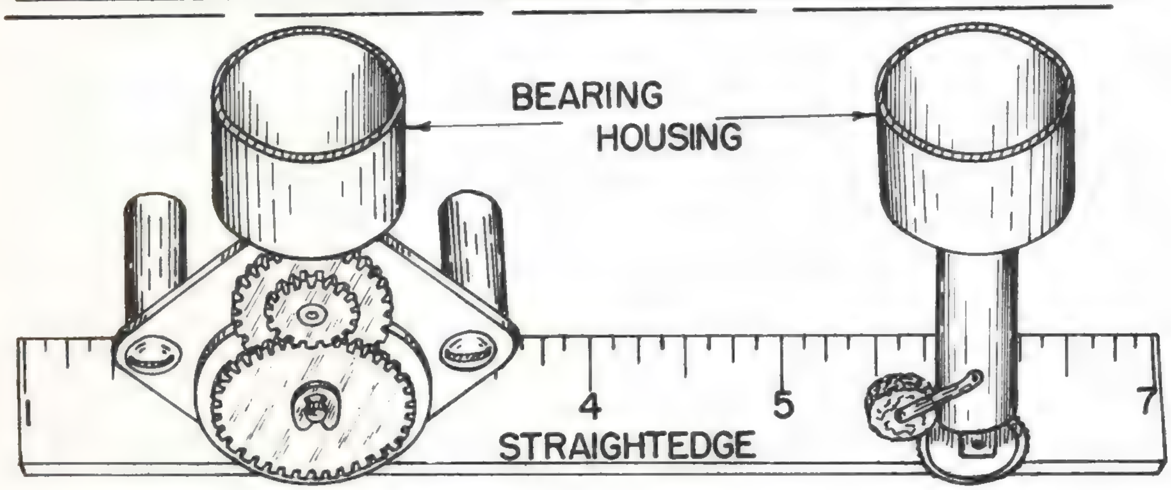
The turbine should have been operating for at least 30 minutes before the greasing operation is started, to allow the motor and the bearings to attain their normal operating temperature. Before the greasing operation is started, remove both drain plugs located on each end of the motor under the bearing retainers. Wipe the area around the grease cup free from any contamination and remove the grease cup. Fill the grease cups with the specified grease and inject the new grease. If there is no indication of old grease appearing at the drain plug opening, insert a wire through the opening into the bearing retainer to insure the drain opening is not clogged. Repeat the procedure of applying the grease until the new grease appears at the drain plug opening. Stop greasing at this time. Allow the unit to run for another 10 or 15 minutes with the drain plugs open to expel any excess grease. THIS IS IMPORTANT. When no more grease comes out of the drain plugs, replace them both.

If the unit has been in service for some time without proper maintenance, or if the wrong lubricant has been used previously, the grease may become hardened sufficiently so that it will not flow out through the bottom drain and may prevent the new grease from flowing through. In this event, and anyhow at the end of each 500 hours of operation, the bearings should be flushed out as follows:

Remove the grease cup (leaving the drain plugs in place) and fill the grease compartment with carbon tetrachloride. Turn on the turbine and let it run for 10 minutes, then remove the

ALIGNMENT
OF
DRIVE WHEELS





ALIGNMENT OF
DRIVE & INKING
WHEELS

FIG. - 48

SECTION III

RECORDER AND DRIVING UNIT

(See also Chapter I, Section VII and Chapter II, Section XI)

The Recorder should be checked and tested periodically (or whenever a need is indicated) for alignment and proper tracking.

To check the alignment of the driving wheels, place a straight-edge against them as shown in Figure 48. Both wheels should be flat against the straight-edge. If they are not, loosen the set screws in one of the three large gears which are mounted on the vertical shaft, turn the shaft so both wheels are flat against the straight-edge and tighten the set screws. To align the inking wheel, place the straight-edge against one of the drive wheels and the inking wheel (Figure 48). Use the side of the driving wheel which is away from the driving gear. Again, the two wheels should be flat against the straight-edge. While this latter alignment is not mathematically exact, due to the difference in thickness of the drive wheel and inking wheel, it is sufficiently accurate for practical purposes.

The pointer (B, Figure 4) must be exactly in line with the inking wheel. Place the straight-edge tightly against the two driving wheels. Set the pointer so it is exactly on 90 degrees (or 270 degrees) and pointed in the direction the inking wheel travels. (The inking roller is toward the front.)

The Telechron driving motors obtain current through slip-rings just above the motors. These rings and brushes must be kept clean and the brushes firmly pressed against the rings.

If the recorder is pushed hard against the desk, banged against the desk edge or otherwise roughly handled, the driving wheels will be sprung out of line. If this occurs, the recorder will draw non-parallel lines on reciprocal headings, and circles of unequal diameter in opposite directions. This is caused by displacing the driving wheels from their proper positions, which is with their point of contact with the map exactly under the center of the vertical spindle.

Test Track

Head the Trainer north and line up the side of the octagon with the base as when compensating the compass, (Chapter I, Section VI). Turn on Trainer main switch. (Turbine should not be running). Turn on the recorder and let it run for 5 or 6 minutes.

Then grasp the end of a wing and walk the Trainer around exactly

180 degrees, using the Base as a reference. Allow it to run for another 5 minutes, then turn back to the previous heading, walking the wing around as before. All three tracks should be parallel within 1/32 inch in 6 inches, and the same distance apart within 1/32 inch. In making this test, do not attempt to fly the Trainer around the turns, or to do it by the turn indicator. Errors in the indicator and inaccuracy of execution would make the results undependable.

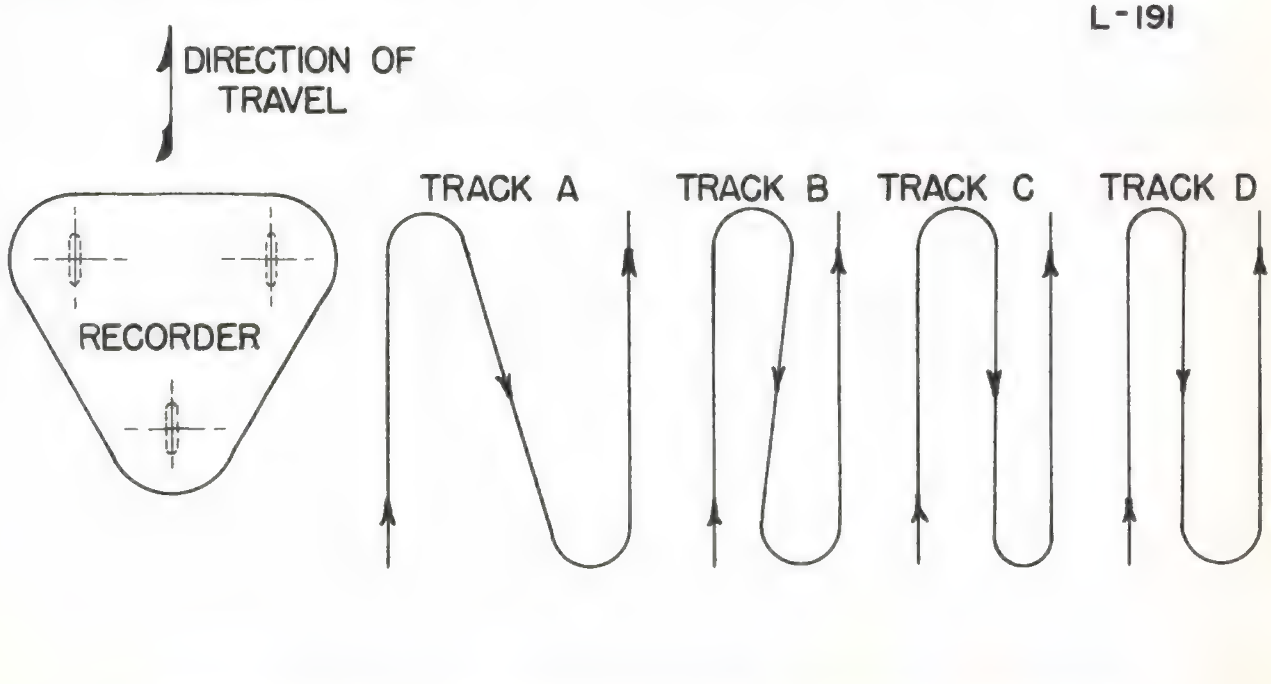
The rate at which these turns are made is not especially important. It is important that the rate be the same in both directions. This can be done quite accurately by stepping the wing around heel to toe, timing the steps with a stop watch at, for example, one step per second.

If the test track is not within limits, another one or two tracks should be run to make sure the fault is with the recorder and not the operator.

If the two outside lines are parallel but the middle one is not, one of the driving wheels is not centered. If the lines are parallel but not equally spaced apart, both wheels are off center.

Figure 49 shows the four possibilities. In "A", the right hand drive wheel should be sprung slightly toward the motor; in Condition "B", the same wheel slightly away from the motor. In "C", both wheels should be sprung slightly away from the motors; in "D", both slightly toward the motors.

L-191



AUTOMATIC RECORDER TEST TRACKS

FIG. 49

AUG. 1, 1941

SECTION IV

CLIMB-DIVE VALVE ASSEMBLY

These valves are extremely delicate and must be handled with care. Part #8080 is the climb valve and controls the vacuum applied to the climb-dive (or "altitude") tank. Part #8075 is the dive valve which controls the flow of atmosphere back into the tank.

These valves handle very small quantities of air and are therefore critical; and their proper functioning depends on their being in excellent condition and correctly adjusted. They are properly set at the factory and the maintenance man, before making any kind of adjustment, should make absolutely certain he thoroughly understands what he is about to do and is sure adjustment is necessary.

Each of these valves has two adjustments: one is the clamp nut to take up any looseness or wear in the threads and the other consists of positioning the lever arm on the needle so that when the arm is against the stop, the needle valve will just be closed.

Adjusting for wear in threads

If side play can be felt in the valve needle, the clamp nut should be drawn up slightly. (Care must be taken to avoid over-tightening). The clamp nut should be tightened one sixth of a turn at a time and the valve tested after each 1/6 turn for tendency to bind. To make this test, swing the lever arm away from the stop and let go of it to see whether the compensator spring promptly returns the arm to the stop. Continue tightening the nut, testing for bind at each 1/6 turn. When tightened enough so the spring does not promptly close the valve, <u>loosen</u> the nut just enough to stop the binding.

Adjusting Needle Valve

There should seldom be any necessity for adjusting the needle valves and before attempting to do so, the maintenance man should make sure it is necessary. There would be need of such adjustment only when it has been <u>proven</u> that the valve itself actually leaks, or when, due to unfavorable operating conditions, the valve has become partially or completely blocked by foreign matter in the atmosphere and has to be removed for cleaning, which is extremely unusual due to the use of air inlet filters.

To adjust the needle valves, the climb-dive assembly must be removed from the Trainer, and a manometer or vacuum gauge capable of measuring up to five inches of mercury will be needed.

When a leak is suspected, time and labor can sometimes be saved by disconnecting the copper tubing from the valve and testing with the manometer before removing the assembly from the Trainer.

In adjusting the climb or dive valve needles, it is imperative that the needle never be screwed against the seat. To do so, no matter how carefully, is to risk ruining the valve. The object of the adjustment is to have the needle, in the closed position of the lever arm, just barely reach the seat but not pressing against it.

Since it is not practical to screw the needle against the seat to find the closed position, it will be necessary to find - with the vacuum gauge - the point where the air flow is cut off. This should be done as follows:

Remove the climb-dive assembly from the Trainer.

Connect a vacuum gauge or manometer to the end fitting.

WARNING: This connection between the valve and the vacuum gauge must be absolutely air tight. Any leak in this line would give the appearance of a leak in the valve and in attempting to close the valve enough to prevent this leak, the needle would be forced against the seat and the valve ruined.

If the leak is slight, proceed as follows:

Loosen the clamp screw in the needle valve lever arm enough so it will be holding only slightly.

Place a 1/32 inch thick spacer, or thickness gauge (Feeler Gauge or any object 1/32 inch thick) between the lever arm and the stop.

Connect one end of a 3/16 inch rubber tube to any convenient source of vacuum in the Trainer and the other end to the elbow fitting on the valve.

Note the rate at which the vacuum gauge moves to its maximum reading.

Remove the tubing from the elbow, and open the valve to allow the vacuum gauge to return to zero, then allow the valve to close (arm against stop).

Hold the vacuum line against the elbow so that the vacuum gauge shows two or three inches of mercury, yet so there is a slight leak between the rubber tube and the elbow.

Place the 1/32 inch gauge between arm and stop, and hold the arm from moving. (Clamp, or otherwise secure it, if necessary).

With a small screwdriver held very lightly, turn the needle about 1/100th of a revolution in the direction of closing, being careful not to entirely cut off the flow to the vacuum gauge.

WARNING: The Dive valve needle has a LEFT HAND THREAD.

Vary the amount of leak between the rubber tubing and the elbow and note the rate of movement of the vacuum gauge.

Continue carefully screwing the needle in, a very little at a time, meanwhile varying the leak between tube and elbow, until the movements of the gauge become sluggish.

When this point is reached, the rubber tubing should be entirely removed from the elbow to allow the gauge to return to zero and then firmly attached to the elbow at each test.

When the needle is in far enough so that the full force of the vacuum only moves the gauge slowly, tighten the lever arm clamp screw slightly and remove the 1/32 inch gauge and allow the arm to move against the stop. (To return gauge to zero, remove suction tubing and open valve for a moment. Then replace tubing.)

If the flow of air has been reduced sufficiently with the spacer in place, it will now be entirely cut off and the gauge will remain at zero.

If, however, there is still a small leak, replace the 1/32 inch spacer and, proceeding as before, reduce the amount of leak. To do this, screw in very slightly on the needle. With the spacer in place, there still must continue to be a slight leak.

Remove the spacer and test as before.

The final adjustment must be one that shows a leak with the spacer in place and no leak with the arm against the stop. If the valves have been in use for several hundred hours, it is permissible to use a 3/64 inch spacer to obtain this condition.

If the Needle Has Been Removed

The valve needle should be given a thin coat of light oil and started in the threads.

Connect the vacuum gauge as previously outlined.

Hold the vacuum tubing against the elbow, varying the leak as before and screw the needle in with the fingers until the movement of the gauge becomes sluggish.

Replace lever arm and compensator and proceed as for remedying a leak.

SECTION V

RADIO AND ELECTRICAL UNITS

1. General Inspection

If any of the radio or electrical units or circuits fail to function properly, a thorough and careful inspection should be made to make sure all connections are tight and all plugs in their proper places. This is important and may save hours of unnecessary work, as transposed plugs or tip jacks may cause symptoms which appear to indicate trouble in units that are actually functioning correctly.

The collector rings in the Trainer base should be cleaned with carbon tetrachloride and the brushes inspected to make sure they are making proper contact. The space between the rings should also be cleaned to prevent any small particle of dirt or metal from "shorting" from one ring to the next.

The cables between the desk and the Trainer should be checked with a test light, ohmeter, or other continuity test, as they may have been damaged by kinking or other rough handling.

2. Radio Chassis

In the event of failure within this unit, a wiring diagram and description of the circuit is given in Chapter lV, Section 1.

3. Radio Range Keyer

This unit requires very little attention beyond keeping it clean, and periodic lubrication.

Cleaning and Lubrication

A good grade of gun oil or light machine oil should be used. A small drop should be applied to each moving part, except cams and cam followers, and any excess should be wiped off. Each gear should receive a drop of oil which will distribute itself as the gear rotates. Very occasionally, the motor bearings should be oiled. Once each hundred hours or so of operation, the small long bearing pin on which the cam assembly rotates should be removed, wiped clean and a little oil applied and worked in. Care should be taken to avoid excess oil and any such should be kept wiped off.

The only cleaning required by the contact points is to occasionally slide a strip of ordinary hard surface writing paper between them.

CAUTION: The knurled knob on the extreme right hand end of the Keyer is part of the cam shaft assembly bearing pin and has a LEFT HAND THREAD. To remove, it must be turned to the RIGHT.

CAUTION: The cam shaft or gears should never be turned backwards by hand because of danger of damaging cam followers.

Adjustment of Contacts

One of the A-N points should make contact just as the other is breaking. There should be no overlap, yet there must be no interval between opening of one contact and closing of the other.

Both fixed contacts should just barely be touching the movable contact when the cam follower is just half way between the high and low parts of the cam. Another check on the adjustment is to see that when the follower is at the low part of the cam, the fixed point which is making contact is pushed away from the adjusting screw head the same distance as the other movable contact is from its screw head, when the follower is on the high part of the cam.

The final test is to listen to the signal with the "Beam Shift Control" in the "on course" position and the "beam" volume set at about "60". No clicks should be heard. If the "on course" signal is not an even tone, back off one of the A-N contact adjusting screws until there is a definite break in the signal; then screw it in again until the key click just barely disappears.

All other contacts should be adjusted so there is an air gap of 1/32 inch between the points when the cam follower is on the highest part of the cam.

Timing of Cams on Cam Shaft Assembly

If the cams are removed and replaced, it is necessary that the spacing between cams be established as before. Each cam has a spot drilled in one side to assist in timing. Ordinarily the cam is placed on the shaft with this spot away from the gear. There are two keyways in each cam so it is necessary to know which one to use. Each cam must use the keyway which, when the spot on one cam lines up with the follower of that cam, permits all other spots to line up with their respective cam followers. Since the cam followers are staggered, the spots will also be staggered. See Figure 29.

In some cases, one can will produce a different pair of call letters if it is reversed. To do this, simply turn the cam over so the spot is toward the gear but with the spot still lined up with its own cam follower.

Adjustment of Motor Position and Drive Gears

If the motor should be removed for any reason, or its clamp screws should become loosened, it will be necessary to adjust its position to obtain proper mesh between the gear on the cam shaft and the heavy pinion which drives it.

The motor mounting screws are in slots which permit the motor and gear train to be raised or lowered as a unit. This unit should be raised or lowered as necessary to make the cam shaft gear and its drive pinion mesh without undue slack, yet so they do not bind. The pivot of the small reduction gear also moves up or down with the motor assembly, in a slot in the keyer frame. Care should be exercized to avoid damage to this pivot, while making adjustments.

CAUTION is advised against unnecessary changing of adjustments. The design and material of this unit are such that adjustments will seldom be necessary if it is not disturbed other than cleaning, lubrication, and normal handling in changing (if any) of cam assemblies.

4. Telegon Oscillator

This unit is described in Chapter IV, Section IX. The wiring diagram, Figure 37, also includes extensive test data for the guidance of the radio repairman.

5. Remote Indicating Instruments

In the event of unsatisfactory operation of these units, before attacking the units themselves, make sure that the Oscillator is functioning properly and that the instrument control mechanism in the Trainer is not at fault. Then check to be sure the trouble is not caused by over-vibration. To do this, simply grasp the vibrator flywheel on the transmitter panel with the fingers and note the effect, if any, on the instruments. If the trouble lies in one of the indicators, the faulty instrument may often be identified by disconnecting one indicator and operating the Trainer, noting the action of the instruments. If there is no change, reconnect this instrument and disconnect the other indicator. WARNING: The Oscillator must be turned off while connecting or disconnecting altimeter indicators, or they will be thrown out of synchronization. (See Chapter I, Section X, "Synchronizing Altimeters".)

If indicators give no indication at all, it indicates a break, or poor connection, in the two wires carrying power from the oscillator to the transmitter or indicators. If the indicators give erratic indications, it is an indication of either a break in the field wires or improper output from the Oscillator. Using an ohmmeter and pair of picks, all connecting lines should be tested for continuity. If the trouble is not found to be in the lines, the instrument should be removed from the panel and the following operations performed. Test the transmitter and indicator at the outlet plugs for the required resistances given in Table I. To test for the required resistances, place one pick on the common, or No. 1, terminal and the other one on each of the three remaining terminals successively, and note whether the values obtained are within the limits. (See Figure 31 for wiring diagram.)

TABLE I

Winding	Ohms
Primary	225-300
Phase 1	900-1100
Phase 2	900-1100

If the required resistances are obtained in both the transmitter and indicators, the difficulty would have to be of a mechanical nature within the transmitters. This mechanism is similar to standard aircraft instruments and repairs should be attempted only by a competent instrument man.

If the required resistances are not obtained in either the transmitter or indicators, the lines from the plug to the Telegon motor unit should be tested. If the trouble is within the motor unit, the unit should be returned to the factory or to an authorized repair base.

SECTION VI

LINK TRAINER VACUUM TURBINE

Description

The vacuum turbine is a centrifugal type blower using four stages (four impellers). The impellers are mounted directly on the armature shaft of the 3/4 H.P. Universal type motor which supplies the power. The turbine parts are shown in Figure 50 .

The unit is designed to operate on 115 volts and will supply 12 cubic feet of air per minute at 4 7/16" of Mercury. It has been found that the Trainer will operate satisfactorily at any degree of vacuum above 4". The remaining 7/16" constitutes a reserve which will partially compensate for fluctuations in line voltage. If the vacuum being supplied to the Trainer by the turbine is tested at some point within the Trainer, it will be about 1/4 of an inch lower than if measured at the turbine.

Under conditions where the noise or heat produced by the turbine and motor are objectionable, it is permissible to relocate the turbine assembly outside the Trainer room and reconnect the turbine to the Trainer with any available tubing having the same inside diameter. CAUTION: If the turbine is located outside the Trainer room, extreme care must be exercised to insure that it is protected from sand or dirt.

Motor

The 3/4 H.P. Universal motor is designed to operate at from 7,000 to 8,000 R.P.M. It will operate on either alternating current or direct current, also on any frequency from 25 cycles to 60 cycles. During normal operation it draws 9.0 amperes. Its speed and in turn the degree of vacuum produced is partially controllable by adjustment of the end bell (described later).

Operating Temperature

The operating temperature of the unit is approximately 50 degrees above room temperature. The temperature of the air space in the base of the Trainer ordinarily is of the order of about 100 degrees Fahrenheit. Consequently, the turbine and motor assembly may be approximately 150 degrees. This temperature should cause no undue concern, as heat up to 200 degrees Fahrenheit will cause no damage. Do not be alarmed if the motor runs too hot to hold your hand on. Remember that any temperature over 110 or 120 degrees Fahrenheit will burn your hand.

Brushes

During operation, a light pin spark may be noted on the commutator at the trailing edge of the brushes. This is a normal characteristic of this type of motor and does no harm if it does not become excessive.

The brushes, like other parts in the motor, are specially designed for the high speed operation of the unit. Consequently, when they require replacement, they must be replaced by the same type and grade. Spare brushes of the proper type may be obtained through the Link factory. When ordering them, the IS number of the unit should be given.

The motor used in the currently produced Trainers utilizes a single wide brush on each side of the motor where previous models used a narrow double brush.

The brushes may be expected to have a normal operating life of approximately 1500 running hours, BUT ONLY IF THEY AND THE COMMUTATOR ARE CAREFULLY AND PROPERLY MAINTAINED. Grease or dirt must not be allowed to accumulate on the brushes, brush holders, or other parts of the motor. During each weekly servicing of the Trainer, the commutator and brushes should be carefully inspected. Make sure that the brushes slide freely in the holder with a slight amount of clearance to allow for expansion when they are hot. If the brushes do not slide freely or if they show any slight gumminess or other fault, they should be removed and thoroughly cleaned, sanding them down slightly, if necessary, to make them slide freely in the holders.

Whenever the brushes are removed, it is important that they be put back in their same holders and in the same positions that they were in before removal. Otherwise, the curved wearing surface of the brushes will not properly fit the commutator and excessive arcing will take place until the brush has worn in again.

To check freeness of brushes in holders, remove the bakelite covers and slide the brushes by means of the brush springs.

CAUTION: GREASE OR DIRT MUST NOT BE ALLOWED TO ACCUMULATE.

When the brushes are worn down to the point where only 3/8 of an inch remains, they should be replaced.

Lubricant

Only two points in the unit require greasing and these are supplied with small grease cups located at each end of the motor. Only a high grade grease having the following general characteristics

drain plugs and allow the carbon tetrachloride to drain off. Replace the drain plugs and repeat this procedure until the carbon tetrachloride drains out clear. Then apply a little light machine oil with a squirt can and let it run for 5 to 10 minutes and then drain it out to flush away the carbon tetrachloride.

After the above procedure is completed, grease the unit as previously described.

Commutator

Due to the relatively high operating speed of this motor, extra care should be exercised to insure that the commutator is clean and in good condition at all times. To facilitate inspection and cleaning, a bakelite cap (on the new models a metal cover) is located on top of the end bell.

By inserting through the opening a clean cloth dampened with carbon tetrachloride, dirt and grease may be removed while the motor is running. If the commutator is extremely dirty, it may be cleaned with very fine (No. 00) sandpaper very carefully used. This will help if the commutator is somewhat rough. NEVER USE EMERY CLOTH.

If the commutator is extremely rough or has ridges, it will be necessary to remove it from the motor and turn it down. (To do this the turbine must be dismantled.) After turning down the commutator, it must be under-cut 1/32 to 3/64 of an inch. If the commutator is turned down more than 1/16 of an inch (radius), it may cause the characteristics of the motor to change.

Dismantling the Turbine

Considerable time was spent in balancing and testing this unit; therefore, when dismantling, the parts should be marked according to Figure 50 . This is important, so that the parts are assembled in exactly the same relative position that they were removed.

Referring to Figure 50 , remove the end head #15, impeller #16, spacer #12, packing #13, deflector head #11, until the unit is completely disassembled. Division head #8 is not to be removed. Next the motor is removed and overhauled.

Reassembly of Turbine

After the motor is overhauled, reassemble and secure it in position.

Check that the packing #4 is in place and tight around the shaft, and if not, a new packing must be installed before the motor is bolted in place. Refer to Figure 50 .

Next secure one impeller on the shaft. Start the motor and make sure that the shaft runs absolutely true.

WARNING: Do not run the motor without at least one impeller on the shaft. One impeller will produce sufficient load to prevent the motor from racing, which otherwise may cause damage.

Proceed to install the impellers and deflector heads as outlined in the following instructions.

Place the first impeller #16-C (Figure 50) on the shaft but do not tighten it. Next place deflector head #11 in the casing and push them until the deflector head is against head spacer #9.

Remove the deflector head from the casing and with a scriber mark the shaft at the impeller hub. Push the impeller back against the division head #8 and return it half way to the mark on the shaft. Tighten the impeller hub bolts a little at a time, being careful not to change the position of the impeller on the shaft or to fracture the clamp. Replace deflector head #11. Place head spacer #10 in position and impeller #16B on the shaft. Next place the second deflector head #11 in the casing and push them both against the head spacer #10. Remove the deflector head #11 from the casing and scribe a mark on the shaft at the impeller hub. Push the impeller #16B back as far as it will go and return it half way to the mark. Tighten the impeller hub bolts and replace the deflector head. With the aid of a screw driver or similar tool, calk the packing #13 firmly back into the groove. If available, use new packing. When calking, check that it is done evenly; otherwise the deflector head will be off center and cause rubbing of the impeller.

Continue this procedure until all impellers are assembled in the casing. Install a new gasket between casing and end head.

When drawing the end head onto the casing, tighten the bolts evenly to prevent misalignment of head spacer and deflector head. When the turbine is completely assembled, connect it to 110-115 volt supply and test. A special fitting is used to adjust the turbine as described under "Adjustment of Turbine Output".

CAUTION: Never attempt to run the turbine with a damaged, repaired, or dirty impeller as their unbalanced condition will cause excessive vibration and may wreck the machine.

Adjustment of Turbine Output

To test and adjust the actual output of the turbine, a special fitting has to be made of an ordinary piece of 2" water pipe, 7 or 8 inches long. On one end of the pipe install a standard pipe cap with a 5/16" hole drilled through it. An additional 3/16" hole is drilled in the pipe three inches from the pipe cap. To this hole a piece of 3/16" copper tubing 1" long is soldered (see Figure 50.1).

Remove the nipple bushing from the end of the turbine and screw in the fitting. A mercury gauge is then connected to the fitting by means of a small rubber tube. Use an actual Mercury column type gauge, if possible, as spring type gauges often are out of calibration from rough handling and so cannot be trusted. Start the turbine and allow it to warm up for at least 30 minutes. Then check the mercury gauge reading and if it is less than 4 3/8" Hg., the speed of the motor should be increased.

WARNING: The line voltage must be between 110 and 115 volts when making this check. Do not attempt to increase the speed of the motor if the voltage is temporarily low as this will result in too high R.P.M. when the voltage returns to normal.

To increase the speed of the motor, loosen the four hexagon bolts, Figure 50.1 , and turn the end bell clockwise just a little by tapping it with a wooden block and hammer. Tighten the four bolts and check. Repeat this operation until proper amount of vacuum is obtained.

CAUTION: The speed of the motor should not exceed 8000 R.P.M.; however, this is not critical. If there is no revolution counter available, it is safe to adjust the end bell so that the turbine produces as high as 4½" Hg.

In some instances it is possible to advance the end bell too far so that the turbine output starts to drop off instead of increase with further adjustment.

The above values are based upon atmosphere at approximately sea level density. At altitudes of several thousand feet the turbine output will be proportionately reduced.

Ball Bearings

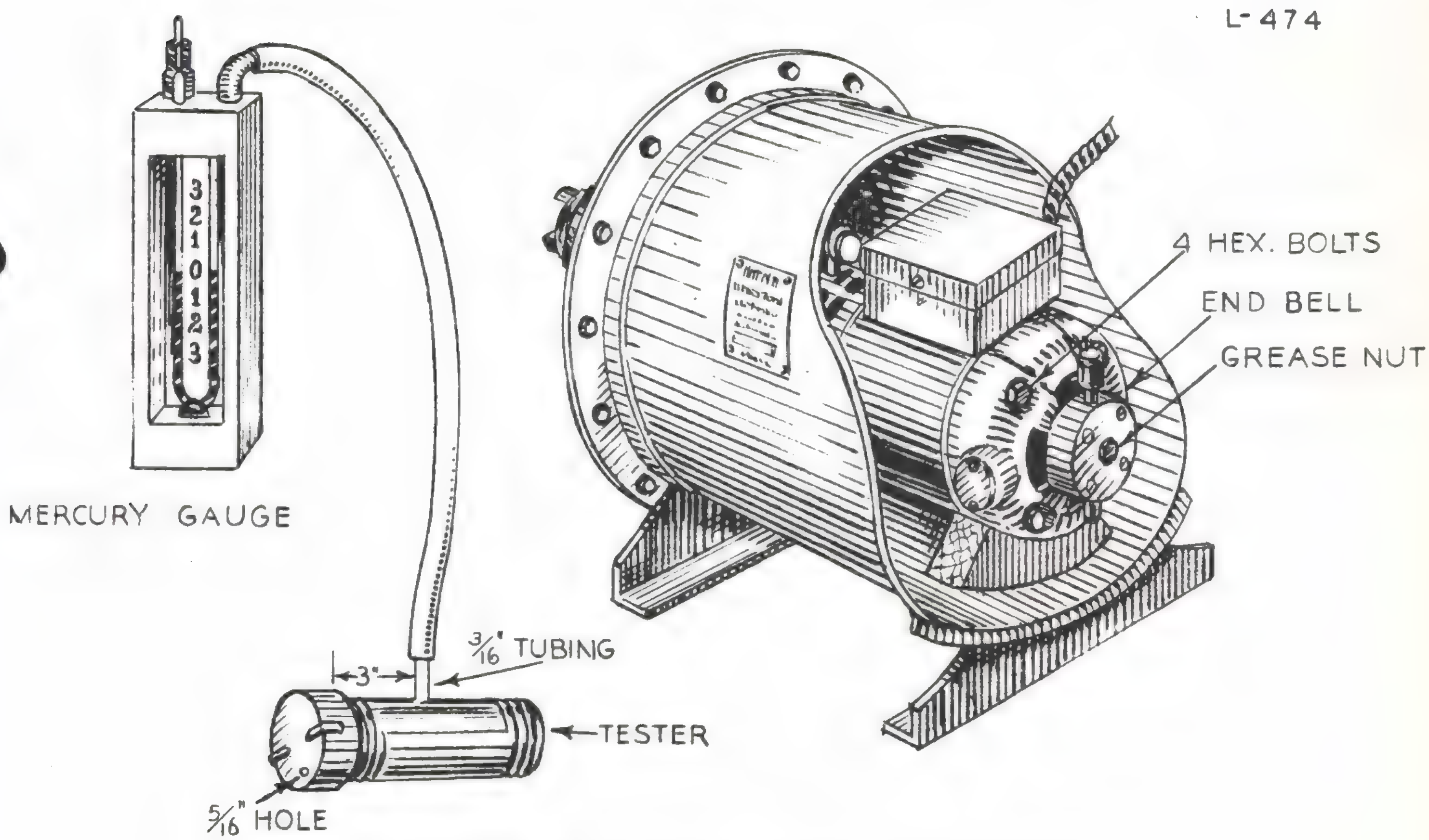
The ball bearings used in the turbine assembly are specially designed for the high operating speed of the unit and if properly lubricated should give long service.

If, however, it should be necessary to replace them, exactly the same types of bearings must be used. Only two bearings are used--one at each end of the motor--and they are interchangeable.

Filter

The turbine motor is equipped with a filter designed to reduce to a minimum the possibility of interference with nearby radio receivers.

This filter is located in a small box mounted on top of the later model units and comprises two condensers across the line with their center connection grounded.



TURBINE AND OUTPUT TESTER
FIG 50.1

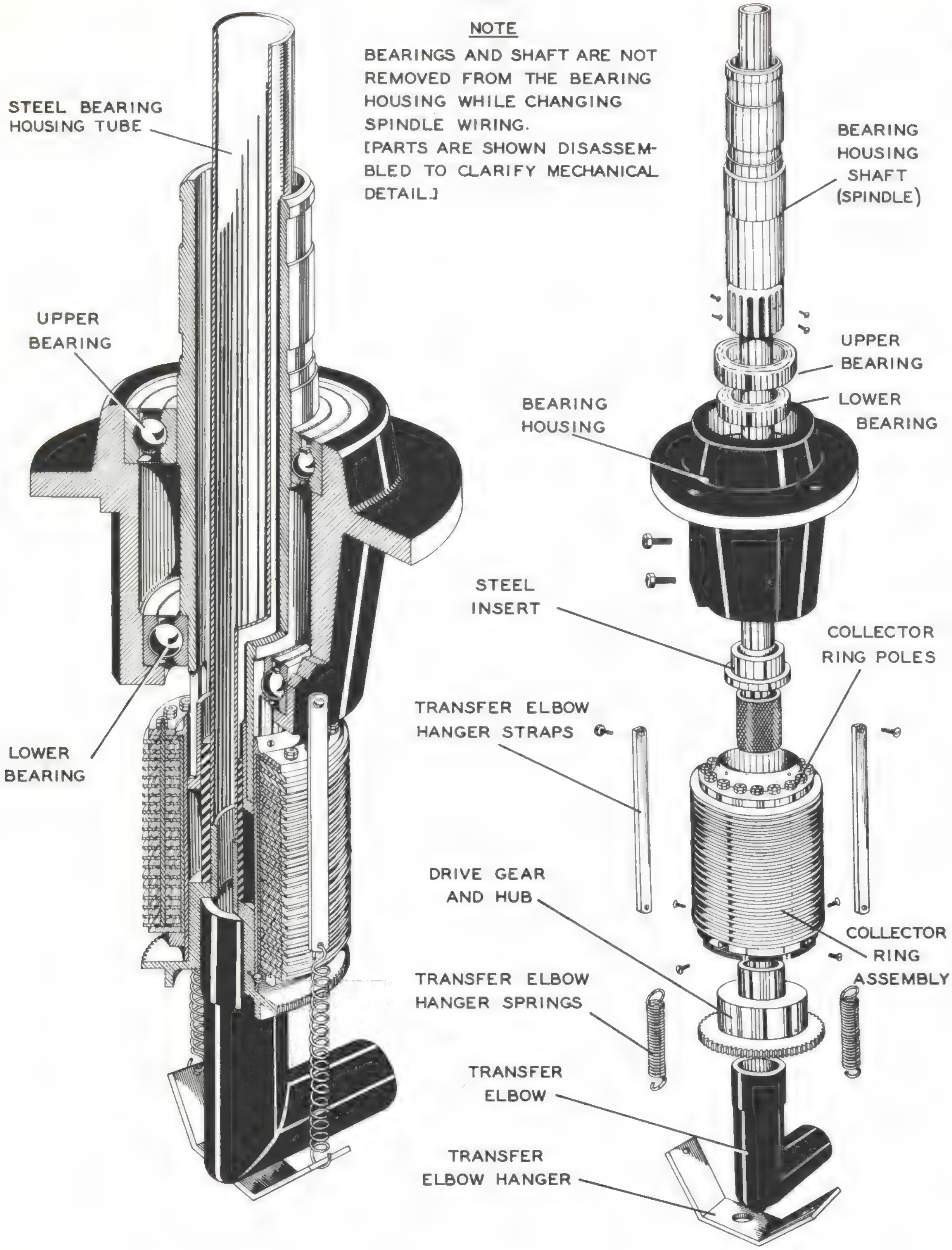


FIG. 50.2

SPINDLE WIRING
INSTRUMENT FLYING TRAINER TYPE C-3
SERIAL NOS. 6000 - 7999
ONLY

SECTION VII

Spindle Wiring

The spindle wiring on Type C-3 Instrument Flying Trainers (serial numbers 6000 through 7,999 **only**) may be changed in whole or in part without dismantling the Trainer. (See figure 50.2.)

The disassembly procedure for removing the old spindle wiring is as follows:

(1) Disconnect the electric throttle control cable at the snap swivel between the wind drift mechanism and the air transfer elbow in the base of the Trainer.

CAUTION: As this cable is spring loaded, the wind drift end must be fed into the mechanism slowly.

(2) Remove the snap ring which secures the electric throttle cable housing to the air transfer elbow located in the Trainer base and push the fitting into the transfer elbow.

(3) Loosen the two bristol setscrews securing the long control shaft to the interchangeable wheel and stick control mechanism (figure 24) inside the fuselage. Next, loosen the cap screw on the control shaft lever arm and slide the entire control shaft about 6 inches to the rear of the Trainer.

(4) Disconnect the control linkage connecting the upper half of the elevator valve and the interchangeable wheel and stick control mechanism at the valve end and swing the rod to the left.

(5) Disconnect the electric throttle cable at the airspeed reversing arm, being careful not to let it slip into the sheathing.

(6) Loosen the setscrew at the pitch action shaft bracket and pull the sheathing through.

(7) Remove all small tubing from conductor elbow.

(8) Loosen hose clamps on conductor elbow.

(9) With cable sheathing and electric throttle cable still attached to conductor elbow, remove all in one piece.

CAUTION: During this operation care should be taken not to damage the cable sheathing assembly.

(10) Disconnect the 21 spindle wiring terminals inside the interconnector box and remove the two spindle wire cables.

(11) Disconnect the air transfer elbow hanger and remove the air transfer elbow.

(12) Disconnect the 23 leads from the top of the collector ring assembly. (There are two extra wires on terminals No. 1 and No. 21.)

(13) Place a scriber mark on the spindle opposite the No. 1 terminal on the collector ring assembly and remove the four round head machine screws securing the collector rings to the spindle.

(14) Remove the entire collector ring, brush and bracket assembly, also the large drive wheel assembly from the bottom of the spindle.

(15) Feed the 23 wires through the slots into the inside of the spindle.

NOTE: The extra wires on terminals No. 1 and No. 21 enter the spindle through the slots opposite terminal No. 7 and Nos. 17-18, respectively. Make sure these extra wires on the new wiring are kept in this same position.

(16) Pull the entire wiring assembly up through the top of the spindle and the floor of the Trainer into the cockpit.

To replace the new spindle wiring proceed as follows:

(1) Check the top and bottom terminals of the spindle wiring for continuity to determine wires No. 1 and No. 21, respectively.

(2) Position the spindle wiring, hose and tube assembly with terminals No. 1 and No. 21 in their correct position in relation to the collector ring assembly (as they would be if attached to collector ring terminals at the bottom of the spindle).

(3) Feed the wires through the fuselage universal joint and spindle.

(4) Remove the short steel insert in the bottom of the spindle and arrange the wires through the slots in the bottom of the hollow spindle.

NOTE: The two extra wires from terminals No. 1 and No. 21 must come out of the spindle opposite terminals No. 7 and Nos. 17-18 when the collector ring assembly is attached to the spindle.

(5) When all of the wires are arranged through the slots, replace the steel insert tightly against the bottom of the spindle.

(6) Slide the collector ring assembly into position with No. 1 terminal on the collector ring assembly opposite the mark previously scribed on the bottom of the spindle and install the four round head machine screws that secure the collector ring assembly to the spindle.

(7) Connect the leads to their respective terminals and reinstall the collector ring brushes and bracket assembly.

CAUTION: When reinstalling brushes make sure they are in proper alignment with their respective rings.

(8) Complete the installation in reverse order of the disassembly procedure.

CHAPTER VII

INSTRUCTION GUIDE, SAMPLE CHARTS, SUGGESTED CURRICULUM, ETC.

SECTION I

INSTRUCTOR'S GUIDE

It is impossible to write a "Guide" which can convey all the knowledge and experience necessary to be a good instructor. Therefore, this Guide cannot be expected to make an instructor of inexperienced personnel. There can be no substitute for training and experience in both the art of instruction and the use of special equipment. It cannot be over-emphasized that, for maximum results, the instructor must be one who is thoroughly familiar with his equipment and capable of doing what he is to teach.

The following suggestions and exercises are the result of combining the experience of several successful Link Trainer and Instrument flying instructors, and their practical value has been proven at the factory-operated Instructor's School at Binghamton, New York.

Unlocking the Trainer

With the student seated in the Trainer, warn him not to turn the switch "on" or "off" until asked to do so.

The instructor will handle the controls while unlocking or locking the Trainer straps. With the student seated in the Trainer, turn on the main switch and "flip" the spin valve in the reverse direction by hand, thus tending to stop the Trainer from spinning. Grasp the controls with the left hand and move the stick or wheel forward and back to "float" the Trainer in the rear lock strap. Unhook the rear strap and lay it in a horizontal position against the stop. Place the left hand on the side lock strap and the right hand on the stick or wheel and move to "float" the Trainer in the side strap. Remove the side strap and place it in a horizontal position against the stop. The "take off" is made without any loss of control on the part of either the student or the instructor.

Relocking the Trainer

Be sure the rough air is turned off. Secure the side lock strap first while steadying the Trainer with the right hand on the stick or wheel. The rear lock strap may be maneuvered into position by using the left hand on the control stick or wheel, juggling it to engage the rear lock strap with the right hand. As soon as the Trainer is locked in position, ask for "switch off" of the ignition. A relatively loud voice should be used by the instructor

as the student probably is still wearing the phones. Swing the Trainer around until the door lines up with the step.

Use of the Phone System

The instructor should bear in mind that nearly all of the student's attention is occupied with trying to keep the instruments reading as they should. It is therefore necessary to speak much more clearly than in ordinary conversation. The rate of speech should be about twenty-five percent slower than normal and full value given to each syllable. While it is desirable to cultivate a pleasant voice, a monotonous smoothness should be avoided as it will not penetrate the already overtaxed consciousness of the student. The student should be instructed to raise his voice slightly and direct it toward the microphone.

Use of Beam Volume and A-N or E-T Controls

When working orientation problems, great care should be taken to insure smooth fading or building up of signal strength. A sudden change is not natural to radio reception and gives information to the student in the wrong manner, especially in "Fade out" problems. It is equally important that the A and N, or Beam Shift Control be given close attention in order to maintain proper continuity of signals from a clear N or A, or E and T, through the twilight to the "On Course". The instructor should watch the position of the inking wheel of the recorder, in relation to the radio station on the map, and move the controls as necessary to make the signals sound right. This cannot be done accurately by setting the controls by sight to any given mark. The instructor should know how the signals sound in actual flight and be able to duplicate them by ear.

There are occasions when it is advisable to exaggerate signals. When a beginner in radio flying is drifting off an "On Course", it is often difficult for him to recognize the fact immediately and he frequently misinterprets A's for N's, or E's for T's. Giving him strong exaggerated signals at this stage will speed up his progress appreciably. As his perceptions improve, the signals should be gradually made to duplicate the actual radio as he will hear it in the air.

General

The instructor should be prepared to hear from most new students in the Trainer, "Why, this doesn't fly at all like an airplane". It should be remembered that in instrument flying, "feel" must be ignored; that the student must "fly the instruments", hence it is not important that the Trainer "does not feel like an airplane". Since feel and

stability are purposely entirely lacking in the Trainer, the student will be forced to learn to fly entirely by instrument. No one has been heard to complain that the turn knob of an automatic pilot does not feel like a RUDDER. The knob is used to make an instrument read as desired and the wheel and rudder should be used with the same thought in mind.

No attempt should be made to rush a student through in any given number of hours. Perfection should be the only goal. Ability to fly on instruments should be built as a carpenter builds a house; the early stages of instrument flying practice laying a foundation for a structure which will be only as strong as its foundation.

To many pilots, some of the maneuvers given in the following exercizes may appear elementary and unnecessary and they will want to skip them and get on to the more interesting radio work. The instructor should not allow this and should never assume knowledge on the part of the student, just as in Navigation - radio or other - the student should never assume but prove. And the best place for the instructor to start being thorough is with the first lesson. The student should be required to prove his understanding of each maneuver by explaining back to the instructor what he is going to do.

If the student has previously acquired the ability to execute the apparently simple elementary maneuvers, he will not be delayed long by having to demonstrate his ability. He can progress rapidly until he reaches an exercize he cannot perform satisfactorily. If a weakness in the student's ability is discovered and corrected in these early exercizes, he may sometime have occasion to thank his instructor for his thoroughness. And the conscientious instructor will enjoy more peace of mind if he knows his students have covered each phase thoroughly.

Exercises

1. Familiarization

With student seated in Trainer, explain thoroughly the 1-2-3 system of instrument flying. Explain the function of each instrument and the method of its control. Unlock the Trainer, have the student close the hood, and continue instruction via the microphone. Request the student to apply a little rudder and note the effect on the turn indicator. Apply the same method to other instruments and their associated controls until it is clear that the student understands the theory of instrument flying.

2. Straight Course. (Gyro caged)

With little attention to airspeed or altitude, practice holding

a straight course. If, for example, the turn indicator needle moves away from center to the right, it must be moved equally far to the left for an estimated equal period of time in order to return to the previous heading. This should be practiced until a course can be held within plus or minus 10 degrees in any five minute stretch.

3. Straight Flight. (Gyro caged)

Hold a straight course, maintaining a predetermined airspeed and altitude. Airspeed should be held at cruising speed, plus or minus 15 M.P.H. Altitude within plus or minus 100 feet and the course within plus or minus 10 degrees.

4. Standard Rate Turns. (3° per second)

Turns of 36, 270, 180, and 90 degrees should be practiced by turn indicator and clock until the errors are not more than plus or minus 10 degrees for each 90 degrees of turn. Airspeed, plus or minus 15 M.P.H.; altitude, plus or minus 100 feet. (The Gyro may be uncaged but the turns should be stopped by the clock; the Gyro serving only to indicate the amount of error).

5. Turns to Compass Headings

These turns should be made by the count without using the clock. Amounts of turn should range from as little as 10 degrees to as much as 360 degrees. The student should count out loud so the instructor may check his cadence against a stop watch. (Gyro may be uncaged but should be used only to indicate the amount of error after the turn is completed). Altitude plus or minus 100 feet. Airspeed plus or minus 10 M.P.H. Error of turn to be not more than plus or minus 7-1/2 degrees for each 90 degrees of turn.

6. Coordination of Throttle and Elevators. (Gyro caged)

Change from cruising speed to slow speed and vice versa. Practice until the maneuver can be done smartly, the altitude held within 100 feet, and the heading maintained within plus or minus five degrees.

7. Climbs and Glides. (Gyro caged)

Practice until the vertical speed indicator can be held at any given rate within plus or minus 100 F.P.M. Airspeed plus or minus 10 M.P.H. Heading plus or minus 5 degrees.

8. Climbs and Glides while Turning. (Gyro caged)

Climb or glide to an altitude predetermined by the instructor. For example, from an altitude of 1000 feet, do a standard rate (3° per second) climbing turn to an altitude of 2000 feet, at 500 feet per minute. Climbing should be started at the same instant the turn is started, and the turn and climb both smartly stopped on reaching the 2000 foot mark. If executed correctly, the maneuver will be completed in exactly two minutes and the recorder will show that 360 degrees of turn was made. A simple analysis will inform the instructor what errors were made by the student. For example, if the maneuver occupied two minutes and fifteen seconds and the recorder indicated that 405 degrees of turn were made, it is obvious that the rate of turn was correct (3° per second), but the student had been slow getting the rate of climb to the desired figure or had not held it at the proper indication. In short, if the vertical speed is maintained at the proper indication, the maneuver takes two minutes. If the turn indicator is controlled properly, the recorder will show 3° of turn for each second the student spent executing the maneuver.

9. Climbs and Glides to Predetermined Altitudes and Headings. (Using clock).

While changing altitude five hundred feet at a rate of 500 F.P.M. do standard rate turns of 90, 160, and 225 degrees. In doing the 90 degree turn, the new heading will be reached well before the new altitude. In the 160 degree turn, the new heading will be reached only a few seconds before the new altitude, and in the 225 degree turn, the altitude will be reached before the new heading. This exercize gives excellent practice in doing several things at once and stopping one maneuver while continuing another; and forces the student to keep close track of several instruments. The instructor should time the turns and changes in altitude with a stop watch.

10. Briefly review Numbers 6, 7, 8, and 9, with "Rough Air".

Airspeed bracket should be reduced to plus or minus 5 M.P.H. Other limits should remain the same.

11. Repeat Numbers 8 and 9 at Gliding Speed.

12. Emergency Pull-up

Descend at 500 R.P.M. at gliding speed to a predetermined altitude. Upon reaching this altitude, open the throttle wide, maintaining same speed, and climb to predetermined altitude. On reaching this altitude, level off and then return to cruising speed. Vary this procedure with turns to predetermined headings while pulling up. Air-

speed, plus or minus 5 M.P.H. except while changing from slow speed to cruising.

13. Stalls Without Spinning

Vertical speed must show "mush" while holding the heading within plus or minus 5 degrees.

14. Spins

Spins should be gone into smoothly, as in an airplane. Do not allow student to suddenly pull the stick or wheel fully back, like he were attempting a snap roll. Student to recover on command from the instructor to cruising speed plus or minus 15 M.P.H. When the speed first comes within this limit, it should not again get outside. The altitude at this time should be held within plus or minus 100 feet, and a straight heading maintained within plus or minus five degrees.

The angular movement possible in the Trainer is, of course, limited. Therefore, the Trainer will reach a terminal velocity and limit of nose-down movement when down against the front stop. In teaching "spins" in the Trainer, it is very important that the student not be permitted to nose down too far and rest against the front stop when recovering. If he is permitted to form such a habit in the Trainer, when he attempts recovery from a spin in an airplane, he will push the controls forward too far or hold them forward too long and put the ship on its back. Permitting the student to build up excess speed should be carefully guarded against.

15. Turns to Gyro Headings

This should be practiced until the student can do good standard rate turns (Instructor timing them with stop watch) and stop on the exact predetermined gyro heading.

16. Use of Artificial Horizon

Practice changing from cruising speed to slow speed and vice versa by reference chiefly to the Horizon. While at cruising speed, have student note the position of the miniature airplane relative to the horizon bar, then have him reduce speed to gliding speed and note the position of the airplane and bar. Having noted the two positions, have him change the attitude so as to put the airplane and bar in their cruising position, maintaining altitude with the throttle as usual, and note that the airspeed returns to cruising. Practice until

the maneuver can be done smartly, meanwhile holding the altitude within plus or minus 100 feet and the heading within 5 degrees.

17. The "U" Track

A signal should be agreed upon so that when the student is ready to start the problem, the instructor will start the recorder. As the student signals that he is ready, he should start the sweep hand of the clock. This course (North) is held for one minute. (See illustration.) At the end of this period, the clock should be stopped, cleared, and started over; and at the same time, the 90 degree turn to the right should be started. The turns may be stopped by the Gyro but the pattern will be spoiled if the turn indicator is not properly controlled throughout the maneuver. The clock should be stopped and started over again at the end of each straight run and each turn.

L-194

TRACK "A"

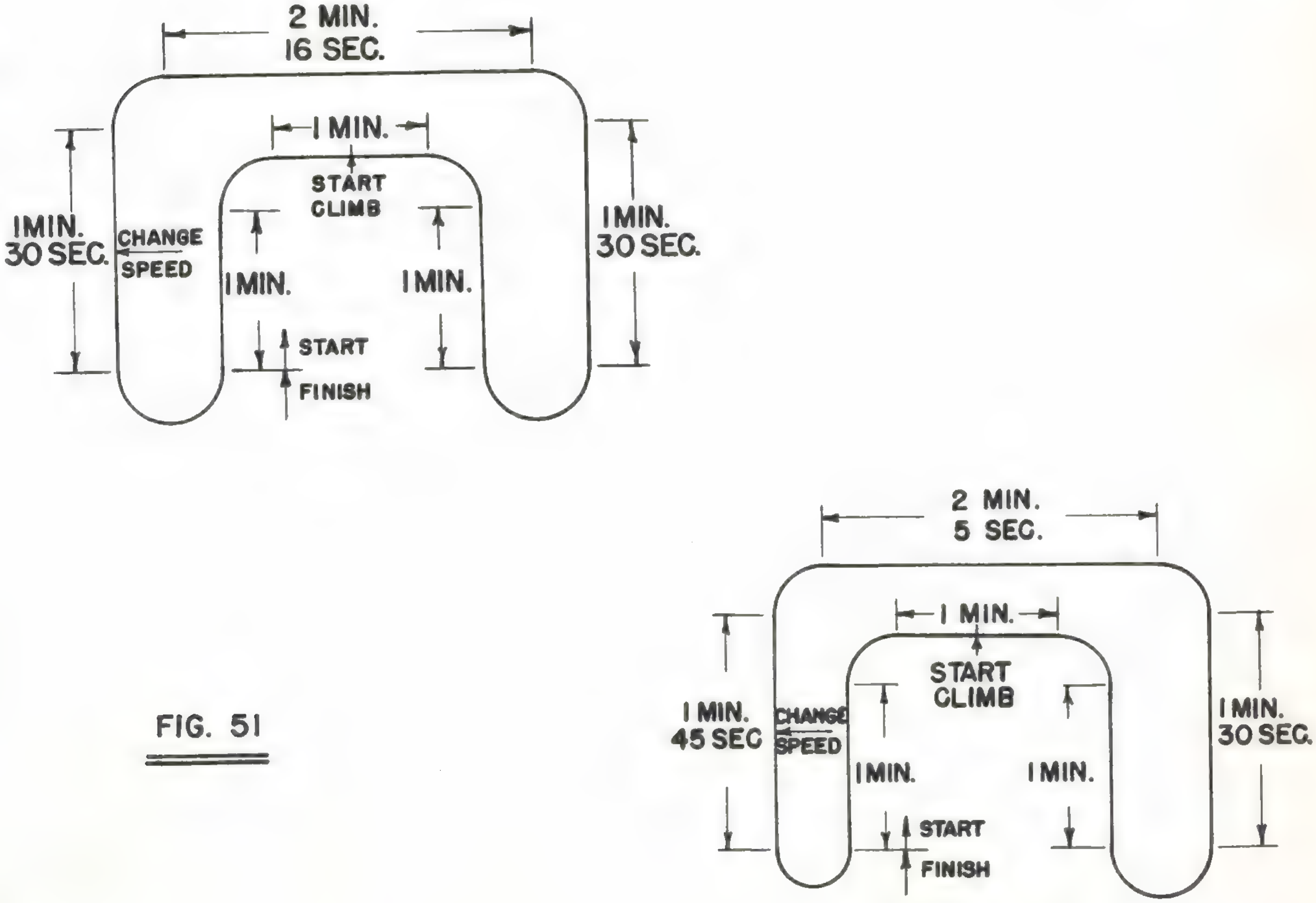


FIG. 51

TRACK "B"

The problem should be started at an altitude of 2000 feet. After coming out of the first turn onto the East heading, the student should climb to an altitude of 2500 feet. At the start of the turn from the fourth leg (Northbound) onto the West leg, a descent of five hundred feet per minute should be started. Continue the glide to an altitude of 1500 feet. This altitude should be held throughout the rest of the problem. On the last leg, prior to going into the last turn, the airspeed should be reduced to gliding speed. As the final turn is completed, the student should signal the instructor who will shut off the Recorder. The starting point and finishing point should be within one eighth inch of each other with "slow" recorder motors. The altitude should be held within plus or minus 50 feet, except when changing to a different level as previously prescribed and the proper airspeed maintained within plus or minus five miles per hour.

The "U" track, (A, Figure 51), as previously described is for use with the constant speed recorder on Trainers which do not have a Wind Drift Device.

Trainers utilizing the Link Wind Drift Device such as models C-3 and C-5 have a variable speed Recorder which faithfully reproduces ground speed. Consequently, the length of time some of the "U" track headings are held must be revised to fit this condition. As will be noted by reference to track B, the west heading is held for 2 minutes 6 seconds instead of 2 minutes 16 seconds. It will also be noted that the latter half of the final south leg must be held for 60 seconds instead of the previous 45 seconds to allow for the slower tracking speed which results from slowing down from cruising to slow flight speed. (NOTE: The above values are for a "no wind" condition.)

Tolerances for the completed "U" track should be the same regardless of which type of Trainer is used. The objective of the "U" track is to test the student as to how well he has mastered the previous maneuvers. If he cannot accomplish it properly, his failure will point out the exercise on which he is weak. If he succeeds, he is ready to advance to Radio Navigation practice.

Since it is possible for rough air to toss the airplane about sufficiently to upset the gyro instruments, plus the possibility of occasional failure of any of the instruments, the student's training should be such as to cover instrument failure emergencies. To this end, various instruments should be covered up in various combinations throughout the basic instrument course. This should be done in such a way and the instructions so carried out that the student is taught to cross check the instruments against one another in such a manner as to enable him to see for himself which of the instruments are functioning correctly.

Located under the lower right rear of the Trainer fuselage is an "Icing Valve". This valve enables the instructor to shut off vacuum to the airspeed indicator and simulate icing of the

pitot head. At suitable times during the course, without warning to the student, this feature should be used.

Located on the instrument panel is a switch labeled "Pitot Heater". While this switch simulates the pitot heater so far as the student is concerned, actually it turns on a neon light located under the right rear longeron near the icing valve. This neon lamp advises the instructor of the action taken by the student. If for any reason the student has permitted his airspeed to ice up and then turns on the pitot heater, the instructor should not open the icing valve, thus putting the airspeed back in working condition, until a suitable time interval has elapsed for the pitot head to "thaw out".

RADIO NAVIGATION AND ORIENTATION

Radio Navigation should, in general, be taught in the Trainer as it is in the air. Practically all known systems may be practiced including approaches to airports. Since any radio station may be simulated, it is possible to practice and memorize the procedure at any particular airport.

Considerable time can usually be saved, with a beginner who is totally unfamiliar with the Radio Range, by having him run his finger slowly along a range station chart, with phone on, while the instructor, by means of the desk controls, gives him the proper signals according to the position of his finger. The student is thus able to learn what the sounds are like, how an A or N gradually blends into the "On Course", and a general picture of what the signals mean, while he is free from the need to watch instruments and able to concentrate entirely on the radio.

Experience has shown that best progress is made by taking up radio flying in steps, or exercises, much as has been done in the preliminary instrument flying.

The first exercise should be merely to follow the edge of a beam. It is recommended that this "edge" be the line where the student can barely distinguish a faint off-course signal hissing through about twenty-five percent of the time. When the student is flying such a course that the inking wheel is following this line, the instructor must be very careful to transmit the proper signal.

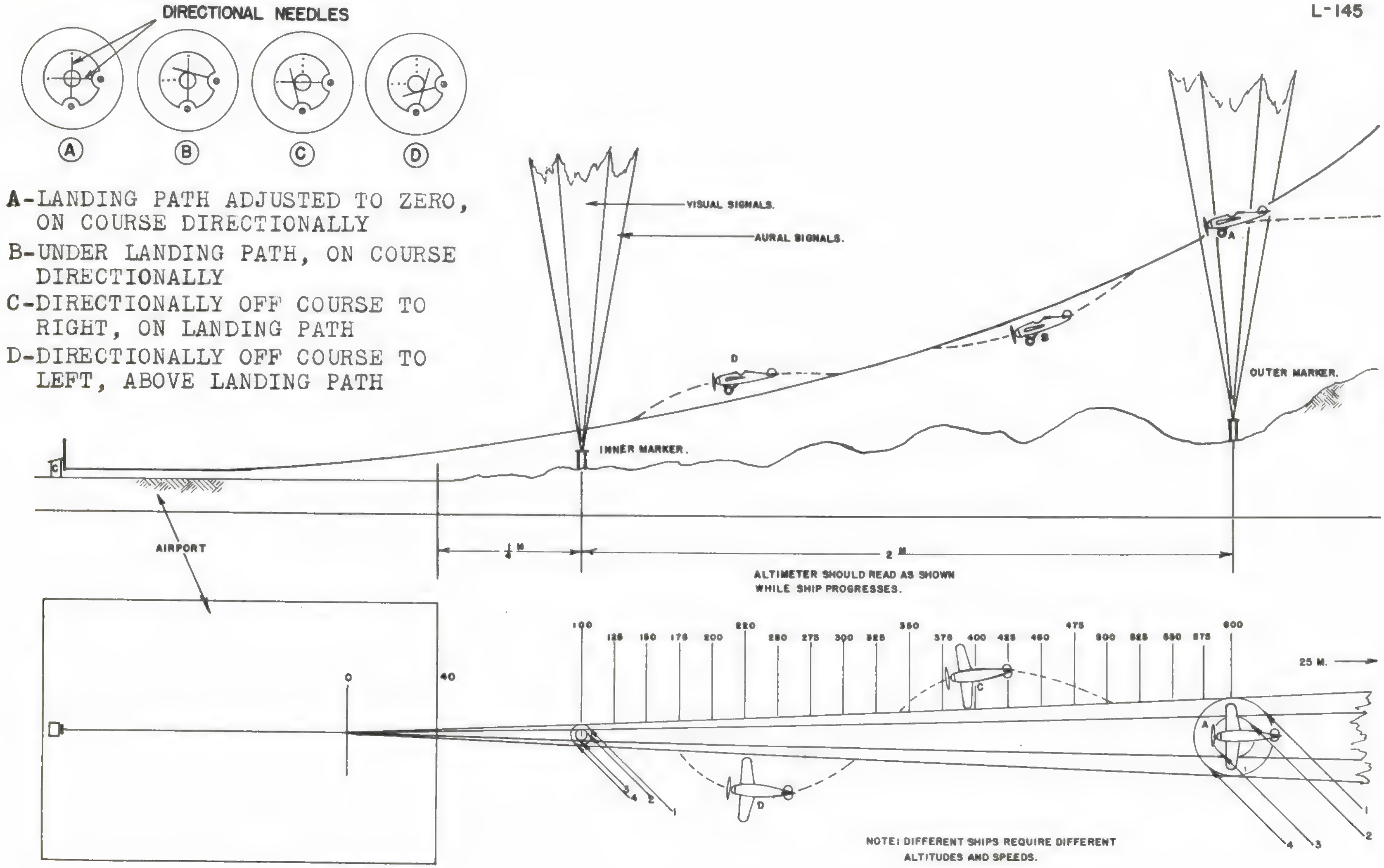
The next step should be that of approaching and getting onto the edge of a beam. This should be done entirely by sound and accomplished by means of a left turn such as will later be used in getting on the beam in a "True Fade-out" problem. Several interceptions of the beam may be made in a half hour lesson. As soon as the student is settled down on the beam edge, the instructor should interrupt and start the recorder over again pointed at the beam at a different angle than before. No time need be lost in resetting the recorder as it does not

matter which way the Trainer is headed. Simply turn the recorder until it is headed at the desired angle to the beam and give the proper radio signal for the position of the inking wheel. (In working a complete orientation problem, it is necessary to have the inking wheel of the recorder pointed in the same direction on the map as the Trainer is headed by compass.)

Since getting onto a beam and following it to the station is the goal of most orientation work, it is important that the two foregoing exercises be mastered before attempting to progress to the more interesting orientation problems.

Each problem should be executed once, at least, with the "rough air" turned on. Occasional problems should be done with various instruments covered up to insure that the student is not learning to depend too much on any one group.

Since Trainer instruction is much less expensive than in an airplane, and can go on regardless of weather, all phases of radio navigation should be <u>thoroughly</u> mastered before considering the Course completed.



CROSS POINTER LANDING SYSTEM

FIG. 56

SECTION III

RADIO RANGE OPERATION

Figures 52, 53, and 54 are typical layouts of radio range stations except that approximate lines of equal signal strength have been drawn in. It is recommended that 24 inch square copies of the sheets be prepared and used for orientation problems. Note that space is provided for the student's name and other data pertaining to the problem. These permanent graphs can be filed away and referred to at any time as a record of the progress and ability of the student.

These three figures show three types of Radio Range Stations: the "square" station, "Scissor", and "Crow-foot". Since signal strength patterns vary widely with the different types, the lines of equal signal strength are drawn in and numbered as an aid to the instructor in giving correct signals. It will be noted on these charts that the signal strength lines are increasingly closer together as the station is approached. It will also be noted that the line nearest the station is numbered "60". From this point to the station, the increase in signal strength is so rapid that lines representing "70", "80", and "90" would be crowded and confusing. These lines (70-80-90) should be imagined and the volume control used accordingly. If the volume control, which is also numbered from 0 to 100, is made to agree at all times with the numbered lines on the chart, the fading and building of signal strength will automatically approximate actual Range signals.

The shaded portion of the beam is always an "on course" signal and requires the setting of the "A" and "N" control at zero. This is the control located at the extreme right on the radio chassis. The dashed lines 5, 10 and 15 on the charts represent the amount to set this control "off course" according to the position of the recorder inking wheel. For example, referring to the chart (Figure 54), the student is flying southeast from theoretical position A. The volume should be set at 25 and the "A" and "N" beam shift control as far "off course" in the "N" quadrant as possible, which is 15. The student flies southeast for 2 or 3 minutes. This brings him to position B. The volume should be changed gradually to approximately 22 during this change of position. The student continues flying southeast, gradually reaching Position C. During this time, the volume changes gradually to 15 and the course beam control is slowly brought from 15 through 10 to 5. At Position D, the course beam control is at zero and the volume is slightly under 10. At Position E, the course beam is at 10 and the volume at 15. Heading northeast, the student returns to the beam. At Point F, he has passed through the "on course" and should be given a slight "N" - about 3 on the

beam control, which again is changed to "O", or "On course", at G.

At this point, the marker beacon is turned on, with the marker beacon volume at "O". This volume is rapidly increased to the maximum setting of 100 and then fades out again, indicating that the plane has passed over the marker at Position H. At this point, the beam control is still zero and the volume is nearly 30. At Position I, it will be noted that the student has run "off course" slightly, and the control settings should have been gradually and smoothly changed to 35 and 5. Continue the proper signals in the same manner throughout the problem. The "cone of silence" at the station is obtained by turning the volume down and returning it again to full volume in from one to ten seconds time, depending on the students "altitude". In fading out the signal to simulate the "cone", the signals will sound more natural if the rate of fade is in proportion to the length of time of the "cone of silence". A small "cone" requires a quick fade.

Attention is called to the fact that the signals at a given distance from the station are considerably louder when entirely "off course", midway between two beams, than when actually on the beam.

Bent beams, multiple courses, etc., may be drawn on the map and simulated by manipulation of the controls. At intervals, a standard weather broadcast should be made. The student should be required to "report in" and all control tower routine should be practiced.

The Instructor must remember that the beam is very narrow, close to the station. When the inking wheel is within a minute or so of the station a solid steady "on course" should not be given unless the wheel is exactly centered on the line which represents the beam, and is pointed exactly toward the station. Giving too wide an "on course" near the station is a fault found in many Instructors.

SECTION V

SUGGESTED CURRICULUM AND REFERENCES

Outline of Suggested Instrument Flying Course of Study

A. Flight Instruments: Description, theory, use, limitations, errors peculiar to each instrument.

1. Turn and Bank.
2. Air Speed.
3. Rate of Climb (Vertical Speed).
4. Magnetic Compass.
5. Standard Altimeter.
6. Sensitive Altimeter.
7. Directional Gyro.
8. Artificial Horizon.
9. Clock.
10. Tachometer.
11. Venturi.
12. Vacuum Pump.
13. Arrangement.
14. Installation.
15. Illumination.
16. Maintenance.

B. Navigation.

1. Introduction - Definitions.
2. Maps (Projections).
3. Compasses.
4. Course Conversion.
5. Navigational Computers.
6. Altitude - True Air Speed Problems.
7. Altitude - Air Speed, Ground Speed, Wind Problems.
8. Wind Triangles.
9. Radius of Action and Simple Interception Problems.
10. Predetermined Flight Plans - Practical Flight Navigation.
11. Theory and Operation of Existing Radio Aids to Navigation and Aircraft Radio.
12. Radio Aids to Flight Operations.
13. Instrument Aproaches.
14. Instrument Landings.
15. Regional and Sectional Charts.
16. Planning Charts.

C. Meteorology.

1. Introduction - The Atmosphere.
   Meteorological Physics, Characteristics and Properties of Air.
2. Meteorological Elements.
   Description, Measurement, Equipment used.
3. Observation and Circulation of the Atmosphere.
   Cyclones and Anticyclones.
   Air Mass Analysis and Theory.
4. Moisture in the Atmosphere.
   Water Vapor, Dew, Frost, Fog, Clouds, Precipitation.
5. Thunderstorms.
   Types, Causes, Stability and Instability.
6. Formation of Ice on Aircraft in Flight.
   Icing Conditions and Various Kinds of Ice.
   De-icing Equipment; Effect of De-icing Equipment and Ice in Flight and when Lading; Carburetor Icing.
7. Weather Analysis.
   Fronts, Weather Map Construction.
8. Symbols.
   Study of Circular "N".

D. Air Traffic Control - Civil Air Regulations.

C.A.R. 20. Pilot Rating.
" 21. Airline Pilot Rating.
" 26. Airport Control Tower Operator Rating.
" 27. Airline Despatcher Rating.
" 50. Flying School Rating.
" 60. Air Traffic Rules.
" 61. Scheduled Airline Rules.
" 91. Aircraft Accident Investigations.
" 98. Definitions.

E. Instrument Flying (see "Instructors Guide").

1. Familiarization.
2. Straight Course.
3. Straight Flight.
4. Standard Rate Turns.
5. Turns to Compass Headings.
6. Coordination of Throttle and Elevators.
7. Climbs and Glides.
8. Climbs and Glides While Turning.
9. Climbing and Gliding Spirals to Predetermined Altitudes. and Headings.
10. Review Numbers 6, 7, 8, and 9 with "Rough Air".
11. Repeat 8 and 9 at Gliding Speed (Rough Air).
12. Stalls without Spinning.

E. Instrument Flying (continued).

13. Spins.
14. The "U" Track.

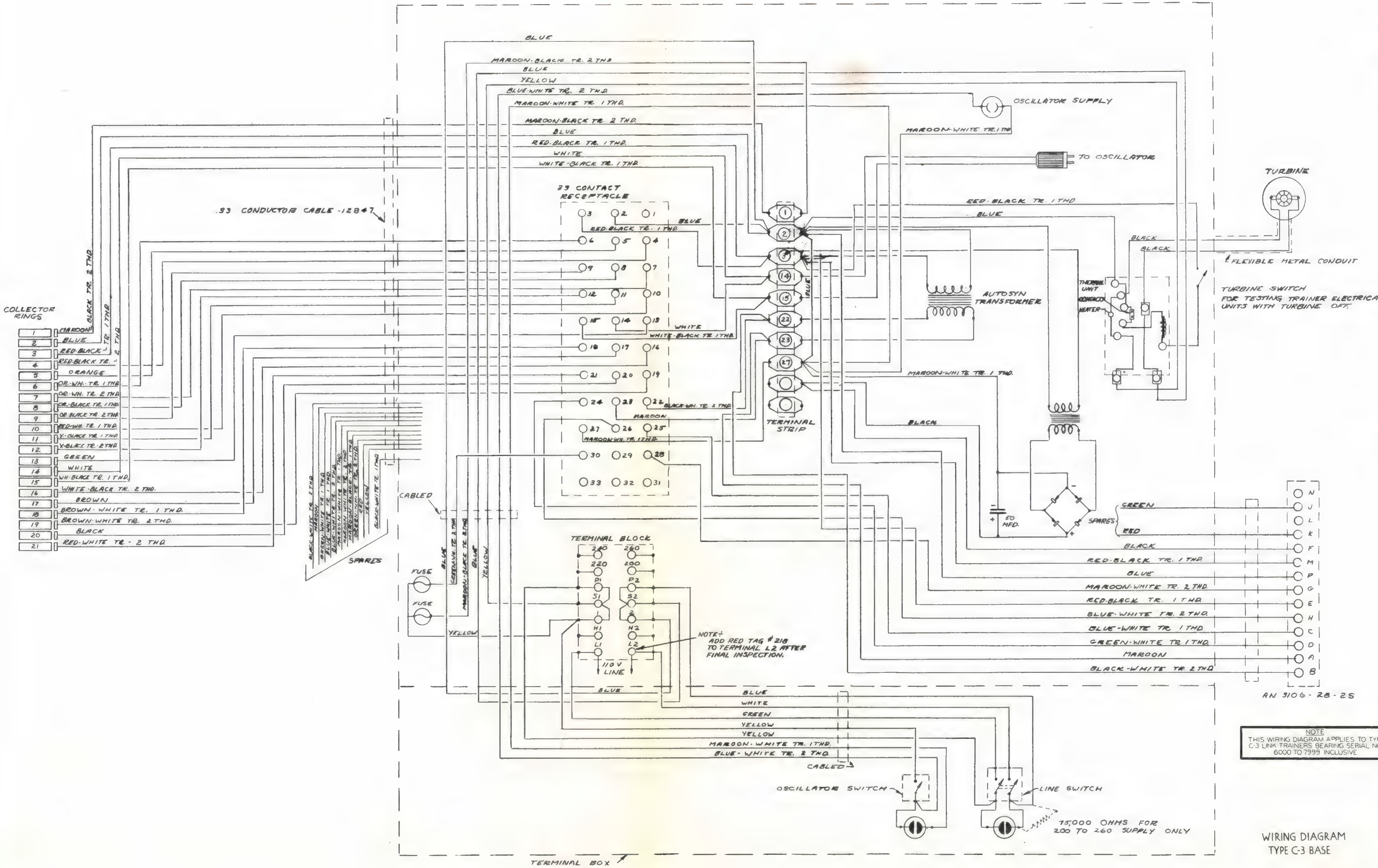
F. Instrument Flying - Utilizing Radio Aids.

1. Following "On Course" Edge.
2. Beam Interception Practice with Multiple Courses.
3. Orientation - 90 Degree System.
4. Marker Beacons (Class M, Z and Fan).
5. Orientation - "Fade-Out" System.
6. Orientation - Parallel System.
7. Orientation - Combination System.
8. Unknown Station System.
9. Multi-Station System.
10. "On Course" System.
11. Close-In System.
    Bisector.
    Parallel.
12. Radio Compass.
    Homing.
    Homing Over Predetermined Track.
    Triangulation.
13. Ground Direction Finding.
14. "Let-Down" Precedure.
15. Low Approach.
16. Instrument Landings.

Suggested References

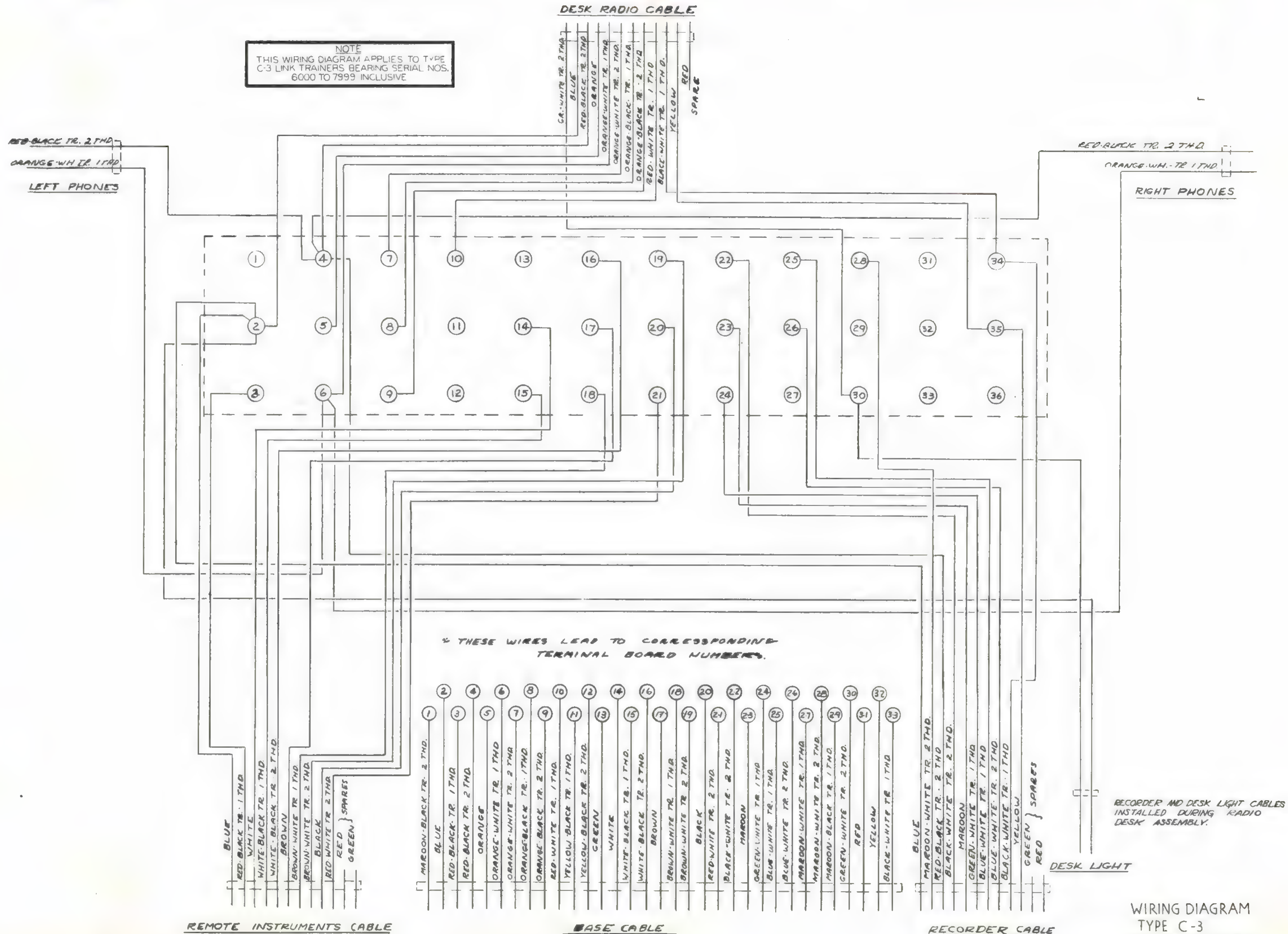
The following books are suggested for their treatment of the subject listed opposite them.

"Airway Radio Range" by Ward D. Davis, Chief, Instrument Flight Trainer, Section, C.A.A.	Range Stations & Orientation
"Instrument and Radio Flying" by Karl S. Day	General Instrument Flying
"Through the Overcast" by Assen Jordanoff	Meteorology
"Air Navigation" by Lt. Comdr. P.V.H. Weems	General Navigation
"Simplified Celestial Navigation" by Lt. Comdr. P.V.H. Weems and E.A. Link, Jr.	

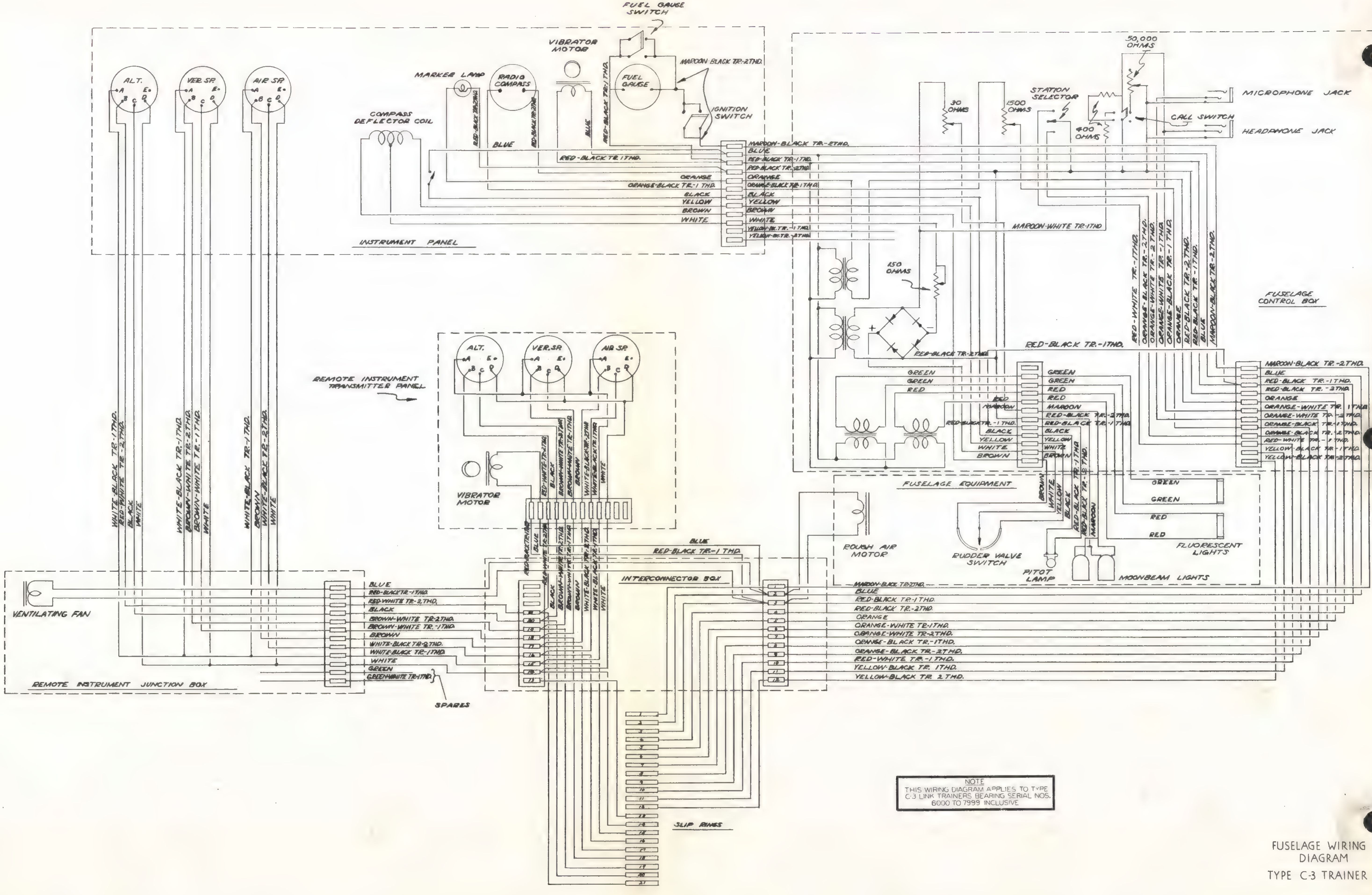


NOTE
THIS WIRING DIAGRAM APPLIES TO TYPE C-3 LINK TRAINERS BEARING SERIAL NOS. 6000 TO 7999 INCLUSIVE

WIRING DIAGRAM
TYPE C-3 BASE



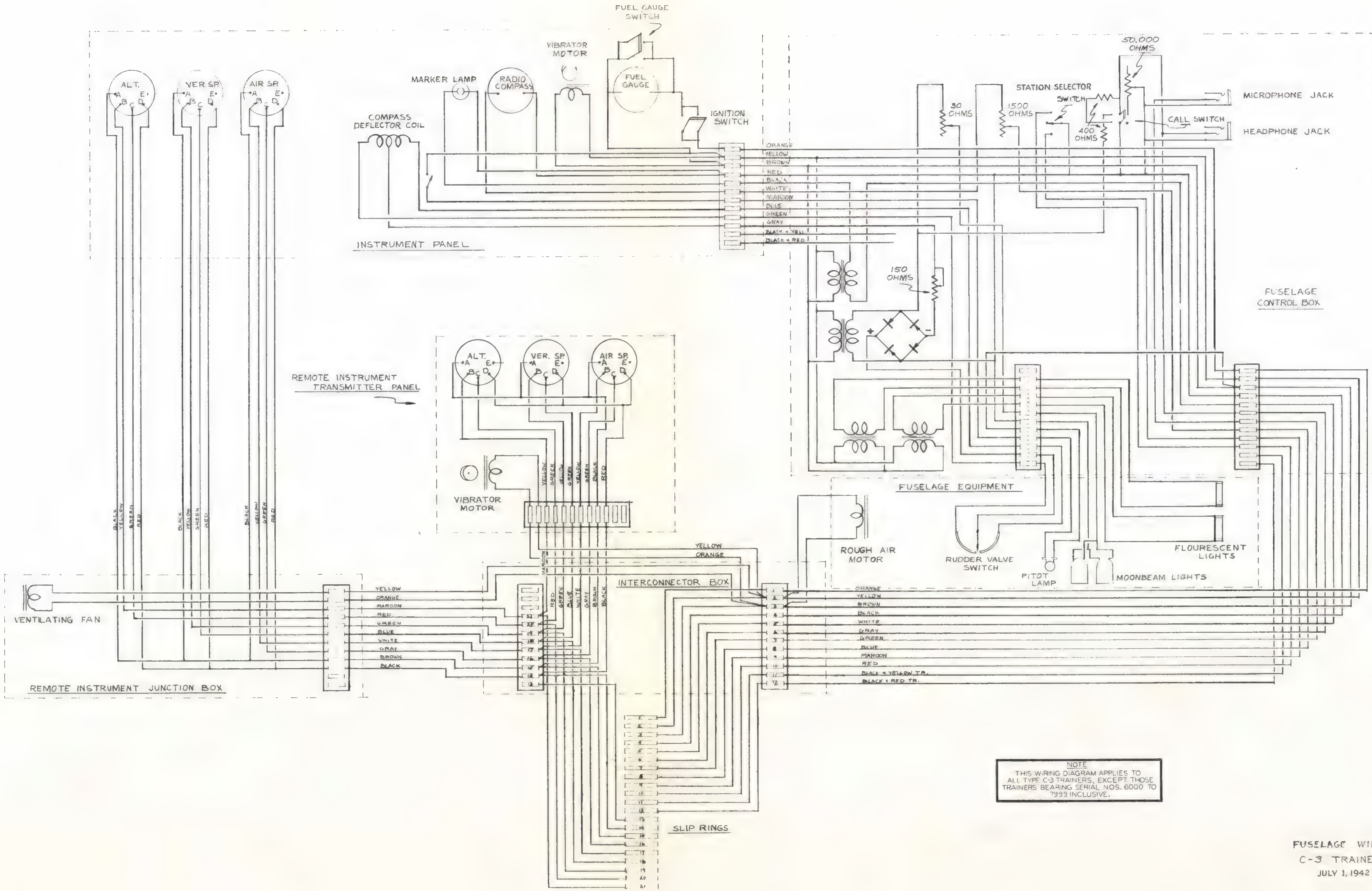
WIRING DIAGRAM
TYPE C-3
DESK JUNCTION BOX



NOTE
THIS WIRING DIAGRAM APPLIES TO TYPE C-3 LINK TRAINERS BEARING SERIAL NOS. 6000 TO 7999 INCLUSIVE

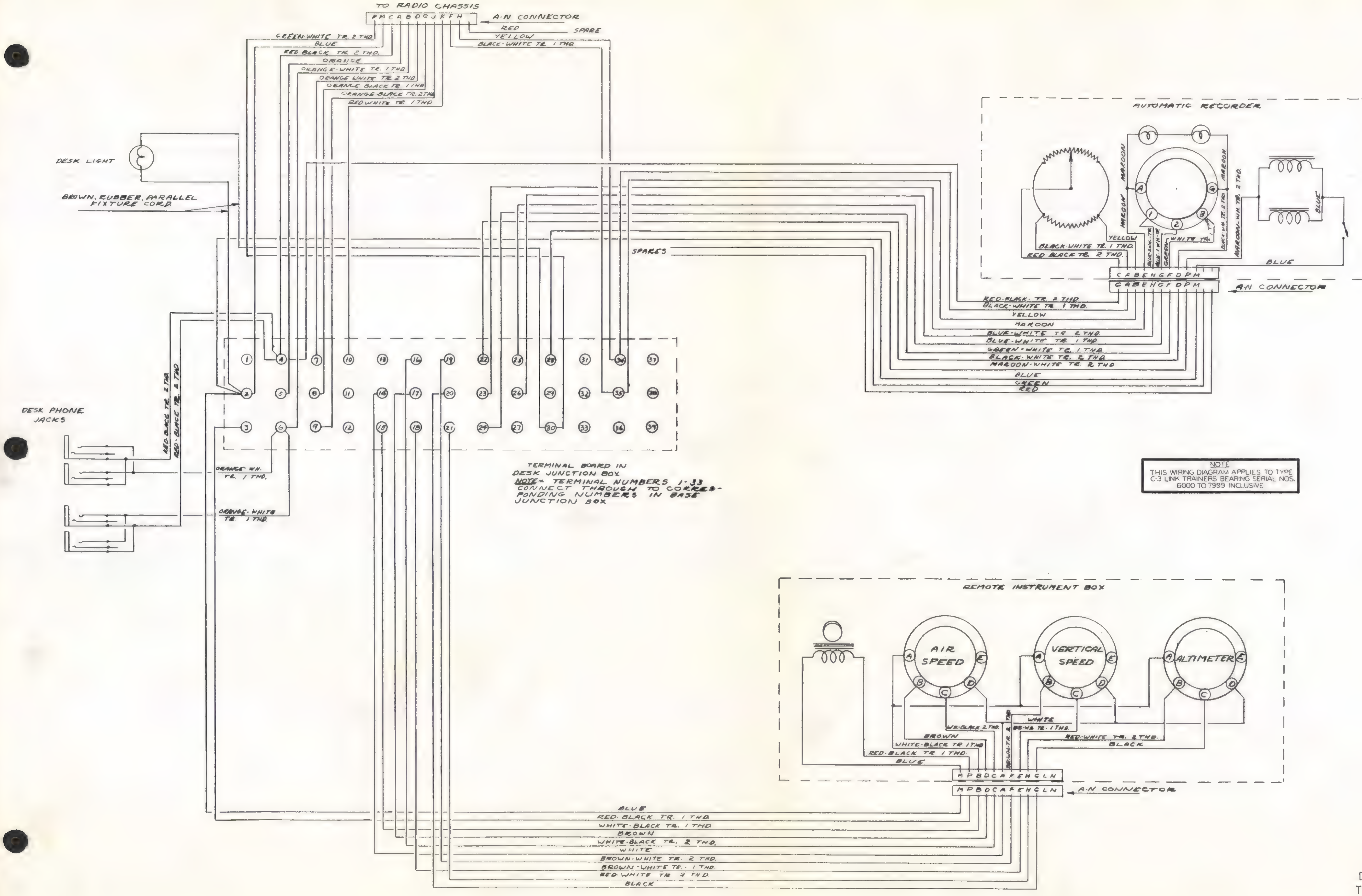
FUSELAGE WIRING DIAGRAM

TYPE C-3 TRAINER

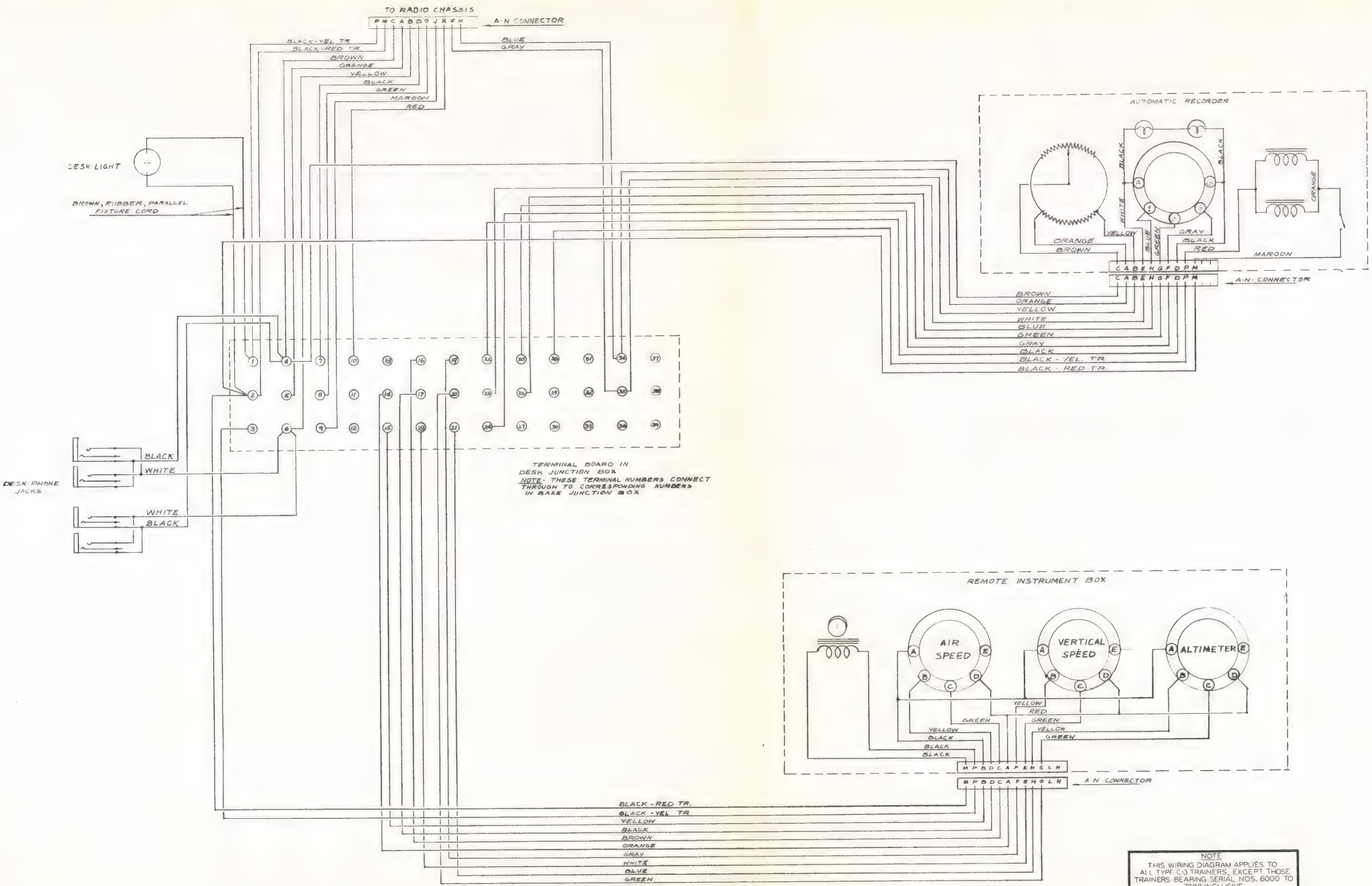


NOTE
THIS WIRING DIAGRAM APPLIES TO ALL TYPE C-3 TRAINERS, EXCEPT THOSE TRAINERS BEARING SERIAL NOS. 6000 TO 7999 INCLUSIVE.

FUSELAGE WIRING
C-3 TRAINER
JULY 1, 1942



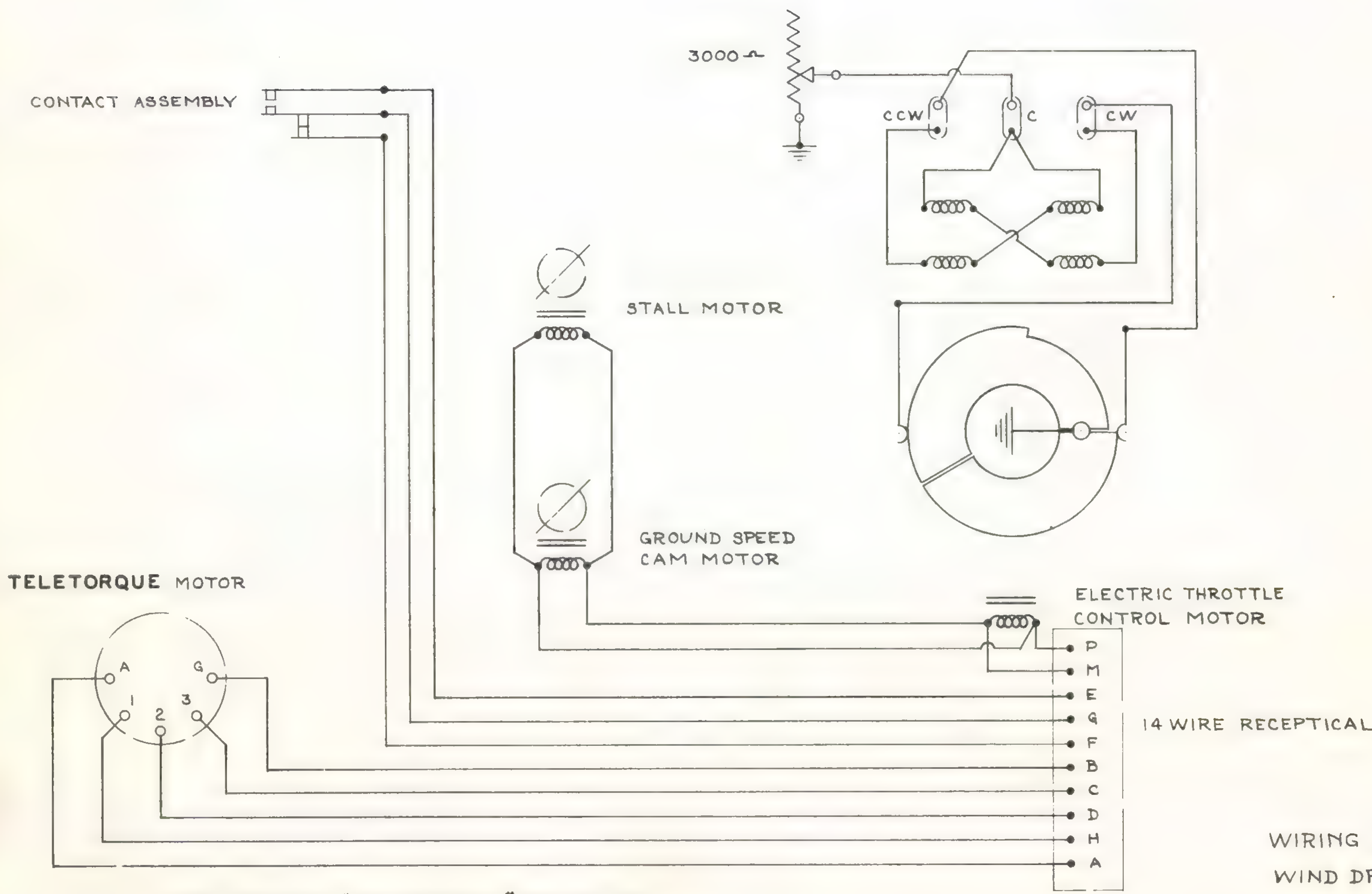
DESK WIRING
TYPE C-3
TRAINER



NOTE
THIS WIRING DIAGRAM APPLIES TO ALL TYPE C-3 TRAINERS, EXCEPT THOSE TRAINERS BEARING SERIAL NOS. 6000 TO 7999 INCLUSIVE.

DESK WIRING
C-3 TRAINER

NOV. 1, 1941



NOTE:- FOR W.D.U. #499 AND UNITS #509 AND UP

WIRING DIAGRAM
WIND DRIFT UNIT

JAN. 1, 1942

Legend - C-3 Radio

Symbol	Name	Description	Part No.
C1	Capacitor	.05 Mfd. 400 Volt Paper	6592
C2	"	.2 " " " "	6591
C3	"	.1 " " " "	6806
C4	"	.01 " " " "	6573
C5	"	.00025 Mfd. 1000 Volt Mica	12816
C6	"	25 Mfd. 25 Volt Electrolytic	10131
C7	"	.01 Mfd. 400 Volt Paper	6573
C8	"	1.0 " " " "	6577
C9	"	.1 " " " "	6806
C10	"	.1 " " " "	6806
C11	"	.02 " " " "	12822
C12	"	.02 " " " "	12822
C13	"	.2 " " " "	6591
C14	"	25 " 25 " Electrolytic	10131
C15	"	.01 " 400 " Paper	6573
C16,C21	"	40-40 Mfd. 25 Volt Electrolytic	10187
C17	"	25 Mfd. 25 Volt "	10131
C18,C19,C20	"	15-15-10 Mfd. 450 Volt "	10148
C22	"	.2 Mfd. 400 Volt Paper	6591
T1	Transformer	Oscillation	10098
T2	"	"	10098
T3	"	Power	10146
T4	"	Microphone	10114
T5	"	Output	10116
R1	Resistor	7,500 Ohm 1 Watt	12855
R2	"	25,000 " ½ "	10038
R3	"	50,000 " Variable	6595
R4	"	250,000 " "	10036
R5	"	700 " 1/2 Watt	10331
R6	"	400 " 1/2 "	10332
R7	"	80,000 " 2 "	10333
R8	"	100,000 " 1/2 "	10138
R9	"	100,000 " 1/2 "	10138
R10	"	1 Megohm 1/2 "	12857
R11	"	500,000 Ohm 1/2 "	12856
R12	"	50,000 " Variable	6595
R13	"	25,000 " 1/2 Watt	10038
R14	"	50,000 " 1/2 "	10039
R15	"	100,000 " 1/2 "	10138
R16	"	2,500 " 1/2 "	10063
R17	"	2 x 7,000 Ohm Variable	8315
R18	"	250,000 " "	10036
R19	"	700 Ohm 1 Watt Wirewound	10331
R20	"	100,000 " 1/2 Watt	10138
R21	"	250,000 " Variable	10128
R22	"	100,000 " 1/2 Watt	10138
R23	"	250 " 1 Watt Wirewound	10041
R24	"	50,000 " 20 Watt Wirewound	10152

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